

SHIP PRODUCTION COMMITTEE  
FACILITIES AND ENVIRONMENTAL EFFECTS  
SURFACE PREPARATION AND COATINGS  
DESIGN/PRODUCTION INTEGRATION  
HUMAN RESOURCE INNOVATION  
MARINE INDUSTRY STANDARDS  
WELDING  
INDUSTRIAL ENGINEERING  
EDUCATION AND TRAINING

June 1976  
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# **THE NATIONAL SHIPBUILDING RESEARCH PROGRAM**

## **Proceedings of the REAPS Technical Symposium**

U.S. DEPARTMENT OF THE NAVY  
CARDEROCK DIVISION,  
NAVAL SURFACE WARFARE CENTER

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**R**esearch and  
**E**ngineering for  
**A**utomation and  
**P**roductivity in  
**S**hipbuilding

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## PREFACE

The REAPS program is dedicated to the development of various computer aided manufacturing processes to reduce cost and improve productivity in the U.S. shipbuilding industry. Wholehearted support from all U.S. yards is a key factor in attaining the broadest and most useful advances.

The 1976 REAPS Technical Symposium, the third annual meeting of U.S. shipbuilders and shipbuilding support agencies, sought to encourage cooperative efforts among U.S. yards. Attesting to the import which the industry attributes to the program, the Symposium was attended by 90 representatives from 48 yards and support groups located throughout the world.

The Proceedings of the 1976 REAPS Technical Symposium contain most of the papers presented at the meeting. The Agenda in Appendix A lists topics and speakers; while Appendix B identifies Symposium attendees.

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## WELCOME

John J. Garvey  
Maritime Administration  
U.S. Department of Commerce

As a senior project officer, Mr. Garvey is responsible for the direction of a number of shipbuilding development projects -- including the REAPS program. He received his bachelor's degree from the U.S. Merchant Marine Academy at King's Point and his Master's Degree in Business Administration from Farleigh Dickinson University. During his career he has published and presented a number of papers on the subject of shipbuilding.



It is a pleasure to welcome you all to the third annual REAPS Technical Symposium. As you are probably aware REAPS is the acronym for Research and Engineering for Automation and Productivity in Shipbuilding -- all keywords in the industry's broad scheme to enhance its position in the world market. The importance of this effort grows daily, and its interest to the shipbuilding community is underscored by the large turnout here today.

REAPS, as originally conceived, is a cooperative endeavor involving U.S. shipyards and the Maritime Administration. It is a total system approach to identify and take advantage of productivity opportunities through the application of automation technology. Developments associated with this program are keyed to specific applications. Projects are not considered complete and successful until they have been implemented under actual shipyard production conditions. This requirement precludes the possibility of a project's failing because of poor implementation of a sound development. It also insures that only those projects with valid objectives will be undertaken. That this approach is viable is evident from the results of the REAPS' program to date.

Let me briefly review a few of these accomplishments. A major responsibility is the continued support and enhancement of the AUTOKON-71 software system. This includes a mechanism for reporting system failures, distributing updated versions of the system, and developing extensive system documentation.

Another REAPS project was a preliminary design for implementing a minimum cost configuration for use in digitizing piping design data. This configuration substantially reduced the cost of preparing input data for various computer-based systems used for the production of pipe manufacturing documents.

Still another project under REAPS' auspices was the development of a low cost remote shipyard graphics and communication terminal. This system was intended for use by shipyard loft departments in processing the input

and output of N/C software systems. Its design was modular for ease in configuring various throughput versus cost alternatives.

REAPS was also responsible for the development of an N/C frame bending machine carried out by Case Western Reserve University. This project was described at last year's symposium, and today, it has resulted in the production of a prototype, fully automated frame bending machine.

Enough for the highlights of past accomplishments. What of the future? The REAPS program has evolved into an exciting new approach to solving the problems facing the shipbuilding community. While the specifics will be elaborated on shortly, I'd like to convey my enthusiasm for the current direction in which REAPS is headed. The new REAPS approach goes beyond AUTOKON support. It is now becoming a vehicle through which shipyards who have entered the world of automation and numerical control along other avenues can share their successes and overcome their failures.

The activities of the new REAPS program are three-pronged:

1. Advance planning to recognize future productivity opportunities,
2. Library and information services to apprise the industry of the latest available information on technology, and
3. R&D program formulation.

The advance planning activity involves the identification of high cost areas and subsequent target opportunities for new hardware and software research and development efforts.

The library and information services activity involves:

1. Publishing the quarterly REAPS Technology Bulletin,
2. Maintaining a library of shipbuilding technology information and selected software programs,

3. Distributing a library catalog and copies of the Bulletin to all major U.S. shipyards,
4. Providing a document reprint and software distribution service, and
5. Holding the annual REAPS Technical Symposium.

The R&D program formulation activity entails both project initiation and project monitoring. Once the advance planning activity identifies opportunities for productivity enhancements, representatives from the REAPS participating yards collectively prioritize these requirements, develop project briefs defining detailed needs, solicit proposals from competent agencies for fulfilling these needs, and determine the best source for their realization.

The resulting development projects are then executed on a cost sharing basis with MarAd funds, monitored by the REAPS program.

Consistent with the broadening technical scope of, and shipyard participation in, the REAPS program, is a shift in emphasis in the program's R&D efforts. It will concentrate on programs or systems which do not rely on a particular N/C software or other production oriented system for applicability.

Examples of projects to be undertaken in the near future are:

1. A Structural Detailing System for defining stiffener intersection details including N/C descriptions of end-cuts for subsequent use by N/C fabrication equipment.
2. A Low Cost Parts Definition System for quickly entering or modifying existing part geometries in an interactive mode through use of a mini computer-based digitizer system.
3. A Sheet Metal Template Generation System for use in developing sheet metal ducting details and subsequent template preparation.

4. A Structural Assembly Aids System for producing parts explosion type drawings of structural units to assist assembly crews in quickly and accurately fabricating structural units. Such developments it is felt will now and in the future provide all U.S. shipbuilders with cost effective technological problem solutions.

I have briefly reviewed for you some of the past accomplishments and highlighted the future directions of the REAPS program. In concluding, I would like to emphasize that REAPS is an instrument for the benefit of all shipyards. A coordinated development program throughout the entire industry is the key to ultimately achieving our goals, and we must take advantage of every opportunity. Let me say I am impressed with the program's development and pleased with the quality of the work it has performed.

During the course of this symposium, we will hear more about REAPS and about other developments throughout the industry. I know we will all gain a great deal from these presentations. Therefore, once again, welcome -- and let's get on with the business at hand.

PRACTICAL SHIPBUILDING RESEARCH  
AND DEVELOPMENT

Ellsworth L. Peterson  
Peterson Builders, Inc.  
Sturgeon Bay, Wisconsin

Mr. Peterson is Director, President and Treasurer of Peterson Builders, Inc. He graduated from the U.S. Merchant Marine Academy and is an active member of numerous marine and civic societies, most notably the Ship Production Committee (SNAME).

We all know research and development goes on in laboratories--what you may not be aware of is that there has been a practical shipbuilding research and development program since 1971. Many worthwhile productivity improvements have occurred in the past five years. Mr. Jack Garvey of MarAd gave a paper to SNAME, in April 1976, which is an excellent summary of the status of these projects. I personally have been on the Ship Production Committee for only a couple of years--and enjoy the association.

The Ship Production Committee is made up of representatives from approximately twenty-four shipbuilders plus the American Bureau of Shipping, U.S. Coast Guard, U.S. Navy Research and Development and, of course, the Maritime Administration whose budget is the backbone of this vital project.

In order to set the pace this morning, we shall show a film about the program. This will help explain and give background for further comments and discussion.

Hopefully, you have the picture. Here are shipbuilders and a user government agency helping themselves improve their capabilities, procedures and productivity to keep competitive in world markets. We are making progress.

We have completed many projects, are in the middle of quite a few, just starting some, and others are only in the planning stage. Who decides what are worthy projects? The industry. How? By having the Ship Production Committee's panels make recommendations as to what projects would be helpful. We poll the industries to see who would use the results of a project. The more yards that would use, the higher the priority; the higher the potential saving, the higher the priority. We then list the projects in priority sequence,. see how far the budget reaches for the year, and submit those-

plus a few extra-to the Maritime Administration for approval. When approved and a shipyard agrees to act as sponsor, a suggested contract is worked out between the sponsor shipyard and the Maritime Administration. I personally am not involved in that cycle.

However, participation is the name of the game, without involvement in a program you are not apt to get much out of it.

Other highlights of the Ship Production Committee:

1. The panel meetings are held at various shipyards and include show-and-tell sessions, a very important way to share knowledge which will improve our industry.
2. The Ship Production Committee has recently appointed a Vice Chairman of the Board who will be calling on shipyards not only to have top management aware of, but also to show the user groups in the shipyard, some of the programs that can save them costs and improve quality.
3. When processes are developed, they are proven to the acceptance of the shipyards and the American Bureau of Shipping or the U.S. Coast Guard, so that they can, in fact, be used.
4. Information is available through several sources. After a project is completed, published information is available from the National Technical Information Service, (U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.) Before that time, some information is available' from the program manager of the project.

5. We try to work closely with the Navy's Research and Development Group, the Coast Guard's Manufacturing Technology Group and the American Bureau of Shipping so that they are also involved. Early discussions help with early approval.
6. Ship Production Committee panels are:
  - SP-1       Facilities (Material Handling)
  - SP-2       Production Techniques  
            (Outfitting Aids)
  - SP-3       Environmental Effects  
            (Shipyard Only)
  - SP-5       Organization and Manpower  
            (Manpower Motivation)
  - SP-6       Standards & Regulations  
            (Ship Producibility)
  - SP-7       Welding
  - 0-34-1-    Computer Aids to Shipbuilding
  - 9-23-1-    Surface Preparation and Coatings
7. Shipyard primary sponsors are leaders; they are Avondale, Bath Iron Works, Bethlehem Steel, Newport News and Todd Shipyards.
8. The most valuable result of this program is that the shipyards are talking to each other at the working level for the betterment of our industry. For example, at our last meeting at Avondale, Mr. Bob Cowart, Vice President of capital recovery for Avondale Shipyards, made a brief presentation to the committee on a recently initiated program. Basically, it involves a plan to sell new material, which a yard finds it cannot use, to other yards, often at a substantial discount from the market price, but still leaving some profit and helping cash flow for the selling yard. Avondale



proposes that all major shipyards develop a computer inventory of excess material which could be accessed by another yard via a CRT display. This would allow a free interchange of needed material, with substantial savings to all involved. All committee members were urged to review Mr. Cowart's proposal, and, if possible, bring it to the attention of the cognizant individual in their particular yard. Comments should be forwarded directly to Mr. Coward at Avondale. This could be the start of standard terms and nomenclature for the material used in shipbuilding and standards are needed.

I believe we have covered the base of the program and can open up for some questions at this time.

THE NEW REAPS PROGRAM  
FOR U. S. SHIPBUILDERS

John C. Williams  
IIT Research Institute  
Chicago, Illinois

Mr. Williams is responsible for the direction and management of projects which involve operations research, computer aided manufacturing development; numerical control applications engineering, industrial and systems engineering, manufacturing planning and technological forecasting. These projects span a wide geographical and technological range.

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The primary purpose of this discussion is to introduce a new version of the REAPS Program. This new concept was first announced in the December 1975 issue of our REAPS Technology Bulletin. At that time we received several shipyard inquiries concerning the new program. Since then we have carried on a continuous dialog, and the new program has taken a definite form as a result of the discussions with those interested yards. I would like to review here the details of that form as we visualize it today.

To properly lay the groundwork for such a discussion, I will briefly review the old REAPS program and how it has achieved its current level of success.

In 1971 a MarAd sponsored U.S. Shipbuilding Industry Advisory Group recognized a void in the area of computer aided shipbuilding. Acting on the advice of this technical advisory group, MarAd acquired rights to the AUTOKON-71 system. At that time, this was the most widely used system, active in more than forty (40) European shipyards.

This action closely parallels the actions of the U.S. Air Force in 1949, when the Air Force in concert with the aerospace industries contracted with MIT for the initial development of numerical control. Subsequent to the development of that technology, the manufacturing industry still did not recognize or accept its potential. Only after the Air Force in 1955 purchased 100 NC machines and strategically placed them in several plants was numerical control accepted. There are many in the NC field today who believe that we would not have NC were it not for the early government effort to reduce the risk and prove the concept to the private investor.

MarAd and the participating shipyards recognized the need to provide maintenance and support for the AUTOKON-71 system, just as the government and the aerospace industries recognized the need to support the APT NC programming system. IIT Research Institute was

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the prime contractor for maintaining the APT system. That effort was sponsored and paid for jointly by the industrial users and the government. In view of that program experience and, I'm sure, other considerations, IITRI was chosen to provide the maintenance and support for the AUTOKON-71 system.

Much of our early effort was devoted to updating and rewriting the documentation of AUTOKON-71 for American users. This also included the documentation of new enhancements being developed by the participating shipyards and IITRI.

Additionally, procedures were established for maintenance of the software. IITRI established a base U.S. version, and all system failures were duplicated on this system. Subsequent fixes were developed, documented, and distributed.

It soon became apparent to all concerned that there was much more to be gained from computer applications in the shipyard than just running the AUTOKON system. A total shipyard program for computer automation beyond AUTOKON was needed if we were to fully exploit and control the power of the computer in ship construction. It was this decision that gave birth to the Research and Engineering for Automation and Productivity in Shipbuilding (REAPS) program; a joint participation program involving five shipyards, MarAd, and IITRI. Its purpose was to identify and address common problems in ship construction. The advantages of such a program are obvious. Participants could pool both the technological know how in identifying and solving problems and their resources to solve a common problem only once not repetitively at every shipyard.

Now under one umbrella (REAPS) we had all we needed to prove the concept:

- Ž Long Range Planning to provide a set of problem definitions and a sense of direction,

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- Software developments with an already functioning software support and maintenance system to resolve those problems.
- Hardware developments with a supporting library to house and distribute specifications and instructional material to shipyards other than the developer.

During this time our original software support was continuing but diminishing in magnitude because the early bugs in the system were already eliminated.

Our REAPS Technology Bulletins were being distributed to the entire shipbuilding community and data from our library was being requested and used by many shipyards.

The REAPS program, a new concept in cooperative developments among several shipyards, was working. The participants were discussing common problems and mutually developing best possible solutions. It has become an ideal example for other industries. It had taken the best elements of the Air Force concept with NC and improved on the concept.

However, there was one thing that was changing--the objectives of our development projects. Originally, they were oriented to a specific computer system; now they were becoming non-system oriented, stand-alone modules with no relationship to a specific computer system or software package. Examples were an NC frame bender that any shipyard could use regardless of its computer system; a pipe digitizing system; a set of standards for U.S. shipyards for holes, cutouts, structural joints, etc.

While REAPS was successful, the benefits from the program could be vastly increased if more shipyards were participating. Also the addition of more shipyards would bring more shipbuilding knowledge to bear on the problems and solutions. A new concept was needed.

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The "new" REAPS program as it has evolved to date is a non-systems oriented program. It is structured to not only embrace but benefit all shipyards, enhancing the probability of transferring common technology across a wider base of U.S. shipyards.

The first step in this new concept was the separation of all AUTOKON related activities from the REAPS program. These were totally removed and repackaged for the AUTOKON yards. Support will continue just as it always has but as a totally separate package. The REAPS program must be purified to encompass only stand-alone automation modules.

Specifically, the new REAPS Program as we see it today, (and it is by no means cast in concrete) contains what we believe are the best elements of the old REAPS Program without the AUTOKON related activities:

- Advance Planning for the proper identification of targets for a development program,
- Technology Assessment of industries and technologies on a world-wide basis that will benefit all U.S. shipyards,
- A Development Program that will address the long range planning targets through a series of projects that either adapt other industrial technology from the assessment stage or fill a technological void,
- **A Technology Information Service that will keep all shipyards abreast of developments internal and external to the program,**
- A Discretionary Development Program that can respond quickly to the participants requirements for small development efforts.

The following is a more finite description of each of these basic elements. Advance planning is not only the quantification and qualification of development needs, it also involves forecasting of inter-

relationships between development efforts. The elimination of a problem at one stage of ship construction may well create several other problems at other stages.

Advance Planning, as it is visualized today, involves the identification of critical activities. This is done through a series of interviews with shipbuilders at several shipyards. This can be viewed as the identification of potential problem areas or targets of opportunity. When these have been quantified and qualified the next step is to develop the framework of the technical approach to the solution. The final step is to make a map of the plan as conceived to this point with the objective of determining the impact of each technical approach on all other elements in the shipyard. After several iterations the impacts should be significantly reduced or eliminated completely. The result is the Advance Plan on which the REAPS Program can act.

IIT Research Institute, like other independent research and development organizations, has a wide exposure to a broad variety of industries and technological innovations, for example, a 600"/min. computer controlled wood router currently being introduced into the furniture industry. Such a device might have application in the mold loft. Whether it does or not isn't significant here. What is important is the broad base of technological innovations that is available to the shipyards.

The Technology Assessment function of the new REAPS Program is designed to capitalize on this broad base of exposure and capture elements of interest to the shipbuilding community. This activity will respond to a request from a shipyard for technical information relative to a particular problem (i.e., a faster more reliable method for making steel plates). This same kind of a request might also come from the Advance Planning Activity. In either case, the industries where similar problems might occur or potentially useful technology might exist are searched to identify potential solutions. These are then analyzed carefully to determine their applicability to the shipyard environment.

Factors such as scale-up, adaptability, skill required, transfer cost, etc. are analyzed to determine the form of any subsequent recommendation. Final recommendations may take one of three forms. First, there may be a problem solution that is directly transferable and need only be purchased and installed. This form would simply be a purchase specification. Second, there may be a problem solution that needs some adaptation for the shipyard. This form would be a purchase specification supplemented with a technical description of the adaptation required. Finally, there may be a total technical void for the problem under consideration. In this case, the form of the recommendation would be a summation of technological approaches that appear feasible. Any one of these recommendations would be communicated directly back to the shipyard for their subsequent actions.

We recognize that the shipyards do not have a full time staff of engineers available to follow up on these recommendations. Someone in the shipyard who already has a full time job will have to take on this activity in addition to his present load, if the problem is to be resolved.

Consequently, we have structured the development program so that our staff will provide full support to your engineers in developing and preparing the necessary project briefs and abstracts necessary to get the project approved and funded by MarAd. Additionally, if outside subcontractor assistance is required to perform the development work we will assist in that effort also. At the shipyards' discretion we will monitor the work and keep the entire REAPS group informed through the preparation and dissemination of progress reports. At the conclusion of the project, we will prepare all final documentation for storage and dissemination of the information, assuring that sufficient data and intelligence are captured for subsequent implementation assistance at another shipyard.

Dissemination of information collected throughout this entire new REAPS program is paramount to its success. There is minimal productivity

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gained unless the information is available to all participants.

Consequently, we believe that the Technology Information Service function is a significant pacing factor in productivity improvements. This will consist of a library where technical data from the REAPS Program and from other sources (i.e., trade journals, technical societies, etc.) is stored, maintained, and disseminated on a regular basis. We will continue to publish the REAPS Technology Bulletin on a regular basis and, if it proves necessary or advantageous, we will increase it in size and frequency. Meetings such as the REAPS Symposium are another vehicle which will serve well to disseminate timely information.

From time to time problems are identified by our participants that need a quick fix. The new REAPS program will contain an element called Discretionary Development which will address this area.

IIT Research Institute in concert with individual technical representatives from each of the participating yards will generate a suggested list of development projects. These ideas will be assembled, developed, refined, and priced out by IITRI. The shipyards collectively will select and prioritize from this list. Within the constraints of available funds, these projects will be performed and reported on in much the same manner as the other REAPS development projects and implemented at one of the participating yards to prove the concept.

To summarize, the overall concept of the new REAPS Program consists of the basic elements that have just been described: Advance Planning, Technology Assessment, Development Program, Technology Information Services and Discretionary Development. As mentioned earlier, it is not cast in concrete; it is still conceptual. However, within the next year, it will be an on-going program. We welcome your comments and questions since only through interaction with the shipyards can this be a program for all shipyards by all shipyards.

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A STATUS REPORT:  
THE REAPS AUTOKON SYSTEM

Patricia D. Taska  
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Chicago, Illinois

Ms. Taska is currently involved in the technical support and maintenance of the AUTOKON-71 System. Her major tasks include processing Analysis Requests, releasing new versions of the system, and coordinating program modifications.

Some past involvements in data processing include: support and modification of a major computer model to evaluate battle-field tactics, the design of a reduction program to handle skin burn data, enhancement of three-dimensional plotting for deformed meshes, improvement, of crane boom analysis test data, and a post-processing program.

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## A STATUS REPORT: THE REAPS AUTOKON SYSTEM

### I. BACKGROUND OF REAPS AUTOKON

#### 1. Description of the System

The forerunner of the REAPS AUTOKON System was acquired over two years ago from Shipping Research Services (SRS) of Norway by the Maritime Administration for use in participating U. S. shipyards. Twelve independent computer programs communicating with a common database accomplish various aspects of ship design and construction:

(SLIDE 1)

- MISC - initializes system database.
- FAIR - fairs offsets.
- DRAW - reads curves stored by FAIR and produces ESS1 output for drawing of the curves.
- TRABO - transfers the bodyplan from the FAIR temporary database to the system database.
- LANSKI - fits longitudinal curves on the hull surface and stores the Tables of Details.
- SHELL - produces N/C burning tapes for cutting shell plates.
- TEMPLATE - produces shell plate templates and frame templates.
- ALKON - parts programming module. ALKON is an interpretive language which lends itself to application in problem solving situations. Its features include capabilities for a vocabulary, stored programs, plane geometry definition, curve fairing, text generation, N/C output production, and many others.
- NEST - stores nesting formats for parts.
- PRODA - generates planning and production data.
- PRELI KON - module for preliminary lines design.
- DUP - utility program for database manipulation.

#### 2. Supported REAPS Versions

Significant modifications have been made to the programs since their initial release to incorporate enhancements, resolve failures, and improve performance. At present, the REAPS Technical Staff maintains several versions of the system, the latest of which is Standard U.S. Version "B" released in May, 1976, to all REAPS participants. The three supported versions

are distinguished by the level numbers of the modules which compose each version.

(SLIDE 2)

Maintenance for the REAPS AUTOKON System which was previously limited only to the UNIVAC installation versions has been expanded to cover both UNIVAC and IBM installation versions. Although modifications for Version "B" were released in a form that can be applied to any installation, direct maintenance of IBM Version "B" will be available later this year. Plans for support of a Honeywell installation version are underway for the next contract year.

### 3. Maintenance Activities

Standard Version "B" was generated as an update to Version "A" resulting from the accumulation of modifications from the SRS Maintenance Central Activity and the REAPS Analysis Request (AR) resolution activity. Since the

(SLIDE 3)

start of the AR activity, REAPS yards have generated a total of 103 AR's, 53 of which reported system failures and 50 of which were requests for enhancements. Eighteen PRELIKON AR's which require extensive modification to resolve have been separately classified as possible projects for pursuit by request of the yard representatives. Thus, of the 85 non-PRELKON AR's received to date, 69 have been resolved.

(SLIDE 4)

Version "B" was released on a magnetic tape accompanied by 57 pages of documentation describing the various improvements to the AUTOKON System.

(SLIDE 5)

The documentation provided a means to compare Version "B" to its predecessor "A", to describe implementation procedures, to note any updates to user manuals, and to describe each update so that non-UNIVAC users and others desiring to selectively update the System could do so.

## **II. FEATURES OF STANDARD U.S. VERSION "B"**

Standard U.S. Version "B" added many useful enhancements to the AUTOKON System without reducing any of the performance improvements inherent in the predecessor Version "A". Nine of the modules were updated to incorporate these changes.

(SLIDE 6)

Enhancements added to the system are described for each module,

## 1. FAIR Modifications

A major enhancement and the correction of a failure compose the set of FAIR updates.

(SLIDE 7)

A feature has been added to the FAIR module to dump pertinent information from the E-file at the user's request. Positions of all stored frames and water lines are printed in tabular form, followed by a detailed description of each faired curve denoting the number of straight line and/or circular elements composing the curve. In addition, the number and location

(SLIDE 8 and 9)

of all inflection points found on a particular faired curve are printed. This feature can be used, therefore, to recognize curves that have not been faired smoothly. The dump may be requested as a stand-alone activity, or may be generated immediately following a fairing run to verify the contents of the E-file. No additional overhead is incurred if the feature is not used; hence, FAIR efficiency is essentially unaffected. Updates to implement this feature were originally contributed by the Bethlehem Steel (Central Technical Division) Shipyard and were subsequently modified slightly for inclusion in Version "B".

An additional modification to FAIR has restored a missing argument in a subroutine call for fairing buttocks in the third loop.

## 2. ALKON Modifications

A number of enhancements have been added to ALKON to create version 10.1,

(SLIDE 10)

As an aid to debugging the source of ALKON geometry errors in a user manuscript, a trace/dump feature has been incorporated that prints all known geometry information from the five element scratch areas where specifications are stored during resolution. The dump is formatted to look like ALKON code for easy interpretation by the user. As a dump, the feature is automatically invoked whenever any one of a set of ALKON geometry errors occurs. As a trace, the feature can be invoked via an option.

(SLIDE 11)

Geometry specification errors, that formerly required a programmer-type person and much time to interpret and correct, now can be handled directly by the loftsmen in much less time. Because the format of the dump looks so similar to ALKON code, it is easy to compare the user's intentions to the geometry area's actual contents and to determine where confusion has occurred. To save time, the dump is produced immediately when a geometry specification error occurs.

(SLIDE 12)

Additionally, the user may activate continuous dumping each time a geometry element is referenced to verify the stored element dimensions.

(SLIDE 13)

Three features have been incorporated to aid the parts programmer in controlling the execution of ALKON based on conditions that can only be known during the compilation phase.

Selective execution of ALKON can be controlled via an option which has been implemented in ALKON. The user can limit ALKON processing to a PASS1 compilation of manuscripts and norms, a compilation followed by an execution only if no serious errors occurred in compilation, or a compilation followed by an execution regardless of any errors that may have occurred. This feature can be useful in the initial checking of manuscripts and norms for syntactical correctness.

Two new words permit the user to generate error messages from norms and manuscripts and to abort norms and manuscripts at will from PASS2. All appropriate processing to properly close the database and terminate the manuscript normally will be done if either operation is performed. These features can be used to prohibit execution or debug problem areas should inconsistent conditions be determined to exist in a manuscript.

(SLIDE 14)

An example of a manuscript where these features have been applied is given.

(SLIDE 15)

Option Y can save execution costs by allowing the user to find and correct all compiler errors before attempting to execute ALKON code. Likewise, while in execution, erroneous conditions can be found by the user and noted with a message, and, if serious enough, can cause abortion of the manuscript.

A complicated part specification that must be included in a manuscript but does not necessarily need to be plotted can be surrounded in the ESS1 output by auxiliary function codes .3. and .4. (ignore on and off, respectively) if so directed by the user. A useful application of this feature might be in debugging stages of part development, where only portions of a part need to be drawn and other portions, although present, could be ignored.

(SLIDE 16)

The vector operations of dot product, cross product, vector normalization, addition, and subtraction have been incorporated into ALKON as in-line capabilities which can operate on vectors up to three components each. Lists are used to manipulate the vectors for input and output.

(SLIDE 17)

Overlength calculations have been incorporated into ALKON to determine, specifically, the web overlength factor, flange overlength factor, and the angle between the web and the flange in the frame plane. These calculations are invoked via an in-line vocabulary word call, passing input from a line of the detailed table matrix to the FORTRAN routine through an ALKON list.

The results are output to a list, as well. This capability was contributed by the Newport News Shipbuilding and Dry Dock Shipyard and has been slightly modified for inclusion in Version "B".

(SLIDE 18)

A number of system failures in ALKON were corrected as well.

- The text height specification by vocabulary word has been modified to operate correctly.
- Options K and L, which previously could not be utilized through ALKON, can now specify any desired input and output character set, respectively, at any point in a manuscript.
- The fairing processor has been modified to turn off auxiliary functions at the end of a contour.
- ☆ An inconsistent combination of startpoint-endpoint and the direction of the line passing between them will be recognized by the geometry processor and the correct specifications will be applied.
- **When a buffer status is found to be out of range** an error message will be generated and ALKON will terminate normally.
- Compilation of a matrix number as an expression has been corrected to operate as stated in the documentation.
- **The occurrence of error message 111 will cause a** manuscript to be aborted to avoid the possibility of erroneous compilation of a statement.

(SLIDE 19)

### 3. DRAW Modifications

Modifications to DRAW primarily have corrected existing failures of the module:

- Incorrect coding which failed to permit drawing of type 4 curves (space curves) has been corrected.
- Vertical axis tic marks which formerly could only be placed at 1 meter intervals can be placed at 2-foot intervals, as the documentation indicates.
- A GRID specification without WNDW parameters which had been ignored will now be drawn using the maximum plot dimensions for a window.

- Curves trimmed by DRAW before plotting will be properly placed within a window that has been determined after, rather than before, trimming.

(SLIDE 20)

#### 4. Other Modifications

Updates to other AUTOKON modules corrected system failures found to exist in AUTOBASE, TRABO, DUP, LANSKI, SHELL, and NEST. A new shell plate expansion method, soon to be fully documented in Volume 5 of the Users Manual Series, was also released with Version "B".

(SLIDE 21)

#### 5. Documentation Updates

Several volumes of the AUTOKON User Manual Series were updated to keep documentation consistent with the current AUTOKON versions. Volume 1, the ALKON Handbook, and Volume 2, the ALKON Programmers Guide were modified to be consistent with ALKON capabilities. The DUP and MISC chapters of Volume 4 were updated, and a new chapter of approximately 170 pages was added documenting the LANSKI program.

(SLIDE 22)

### III. PROJECTS IN DEVELOPMENT

#### 1. Simplified ALKON

When the AUTOKON System is implemented at a new yard, personnel must undergo a period of orientation and training to learn to use the system's features. Feedback from yards who have gone through this procedure indicates that learning the ALKON language seems to be one of the more difficult tasks to accomplish for persons unfamiliar with programming techniques. Even for programmers, the principles of parts definition can become obscured by the complexities of the language and I/O syntax requirements. For an experienced user, the flexibility of ALKON is a desirable quality, but the beginner needs a simpler, more basic, approach to parts specification.

To achieve a transitional medium, effort is currently in progress to develop a Simplified ALKON language with a shorter, more basic vocabulary which will assume many defaults that must be explicitly defined under regular ALKON.

The principles of parts definition are unchanged, although the scope of ALKON capability is greatly reduced along with the simplification. For example, Simplified ALKON

- can describe only one part at a time (i.e. may build a contour into only one open matrix);



can reference only a limited number of stored contours: a lofting contour, an auxiliary contour, and a parallel contour;

- cannot modify a stored part; and
- has limited text and visual NC output capabilities,

(SLIDE 23)

On the other hand, many features are still available from ALKON to Simplified ALKON, such as:

- norms and repetitions may be written, stored, and invoked;
- full plane geometry description capabilities exist; and
- the AUTOKON database is used unchanged.

Only the PASSI compiler needs to be modified to compile Simplified ALKON to insert default coding where required and to translate Simplified ALKON statements into their ALKON counterparts. Some examples of Simplified ALKON and their equivalent interpretation in ALKON follow.

(SLIDE 24)

The effect of TFR is to place the contour in a matrix buffer and to load the Table of Details with proper information. The Simplified ALKON user need not be concerned with the frills, all he requires is the ability to reference transverse frames.

COPACON causes a contour to be copied from one buffer into another, and in Simplified ALKON application, the auxiliary contour will be copied into the lofting contour buffer.

ACON and LCON are minor simplifications of the reference to the auxiliary contour and lofting contour buffers.

LONG causes a line of the Table of Details to be referenced and various list values to assume the values for manipulation in a norm or manuscript.

In addition to the simplification of ALKON statements, Simplified ALKON will have new features that can aid the user. The \$ character can be used to denote a missing coordinate or angle-value which the geometry routines must supply. It is a useful feature for relocating coordinate systems, specifying points, etc. when only one coordinate is significant and the other is determined uniquely by that one. Intersecting into a known contour is an example of its application.

(SLIDE 25)

he use of an implied do-loop in a call to a norm or repetition eliminates the formalities of ALKON'S DO statement and label while affording the capability of repeated calls to the norm or repetition.

(SLIDE 26)

As the Darts Drogrammer becomes more capable, he may gradually make the transition from Simplified ALKON to standard ALKON by switching vocabularies and cautiously combining the features of both systems. The AUTOKON database may be used so that parts may be stored and referenced by both systems. Simplified ALKON is upward compatible with ALKON to guarantee that its use as a transitional learning tool will not require any "unlearning" of techniques.

The preliminary specifications for implementing Simplified ALKON were distributed a few weeks ago to the REAPS participants for review and comment. Assuming that responses are received by mid-July, an experimental distribution will be completed by the end of October.

## 2. Norms Enhancement

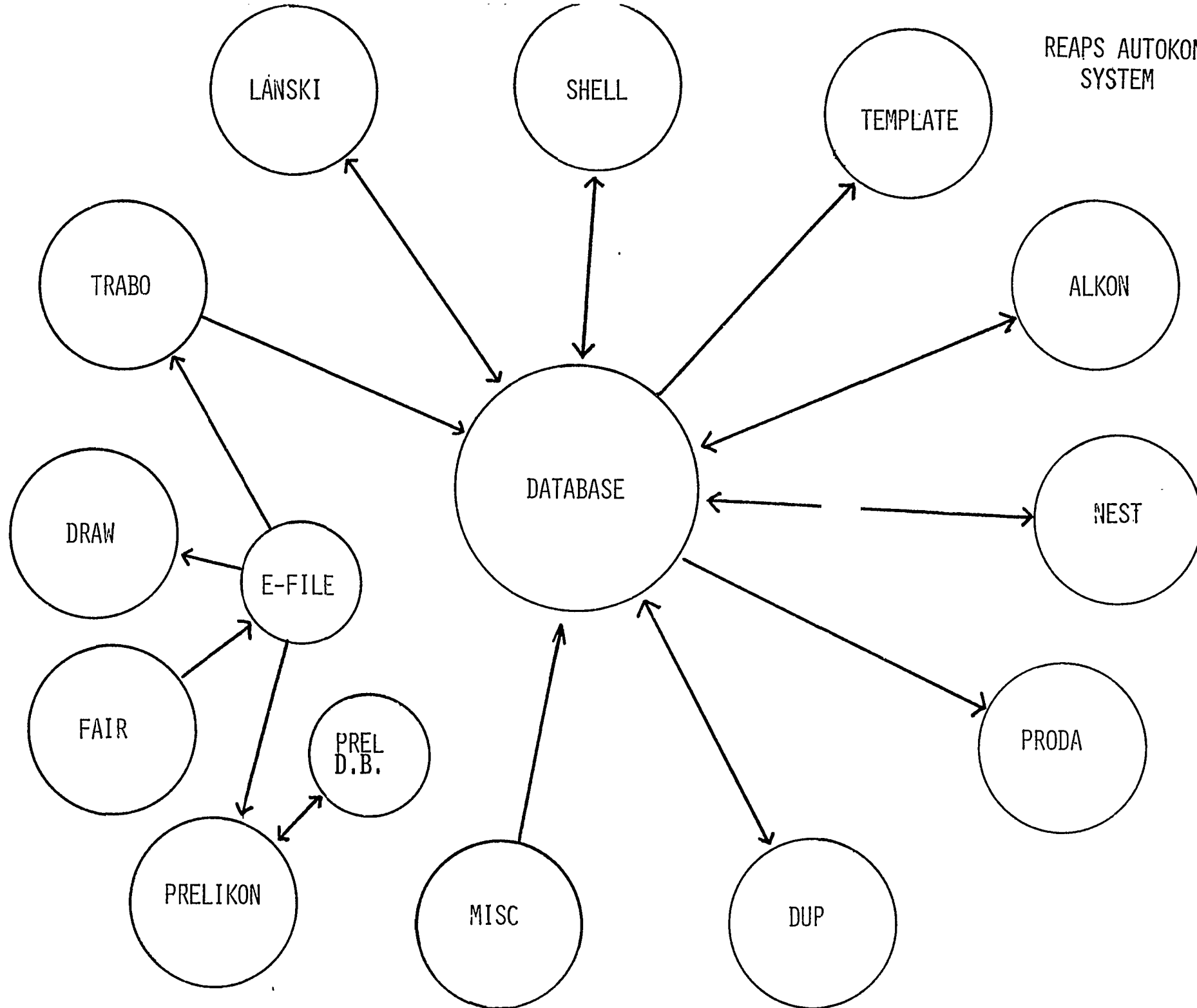
A second project was undertaken by the Technical Staff in conjunction with representatives from the REAPS yards to replace, modify and add norms to the standard AUTOKON system library, thus evolving an improved tool for use by U.S. shipyards. Loftsmen from the participating yards having norms experience and REAPS Staff members formed the Norms Library Enhancement Task Group in January and have since held several meetings to review and modify the norms library.

As a result of the Task Group Meetings, 33 of the norms documented in User Manual Volume 3 were suggested for revision, four new norms were proposed for addition, and three were deleted from the library. Priority assignments for modifications were established. A Technical Memorandum containing preliminary specifications for the suggested revisions was published.

(SLIDE 27)

Fifty key norms which are repeatedly used in the yards in a production environment were identified as requiring extensive documentation in Volume 3. Norms of greater complexity requiring several explicit examples were noted for expanded documentation as well. To date, most of the Priority 1 and 2 norm revisions have been implemented. A second Technical Memorandum describing the changes for fourteen revised norms, two new norms, and documentation updates for seventeen more norms was published. It also included a cross reference list of norms and a summary of the 50 identified key norms. An interim system update incorporating the modified norms library is scheduled for mid-November, as well as a documentation update to Norm Descriptions, Volume 3 of the User Manual.

The joint activity of the yards and the REAPS Staff to identify, improve, implement and test system library norms will lead to a more efficient and relevant library for all REAPS AUTOKON users.



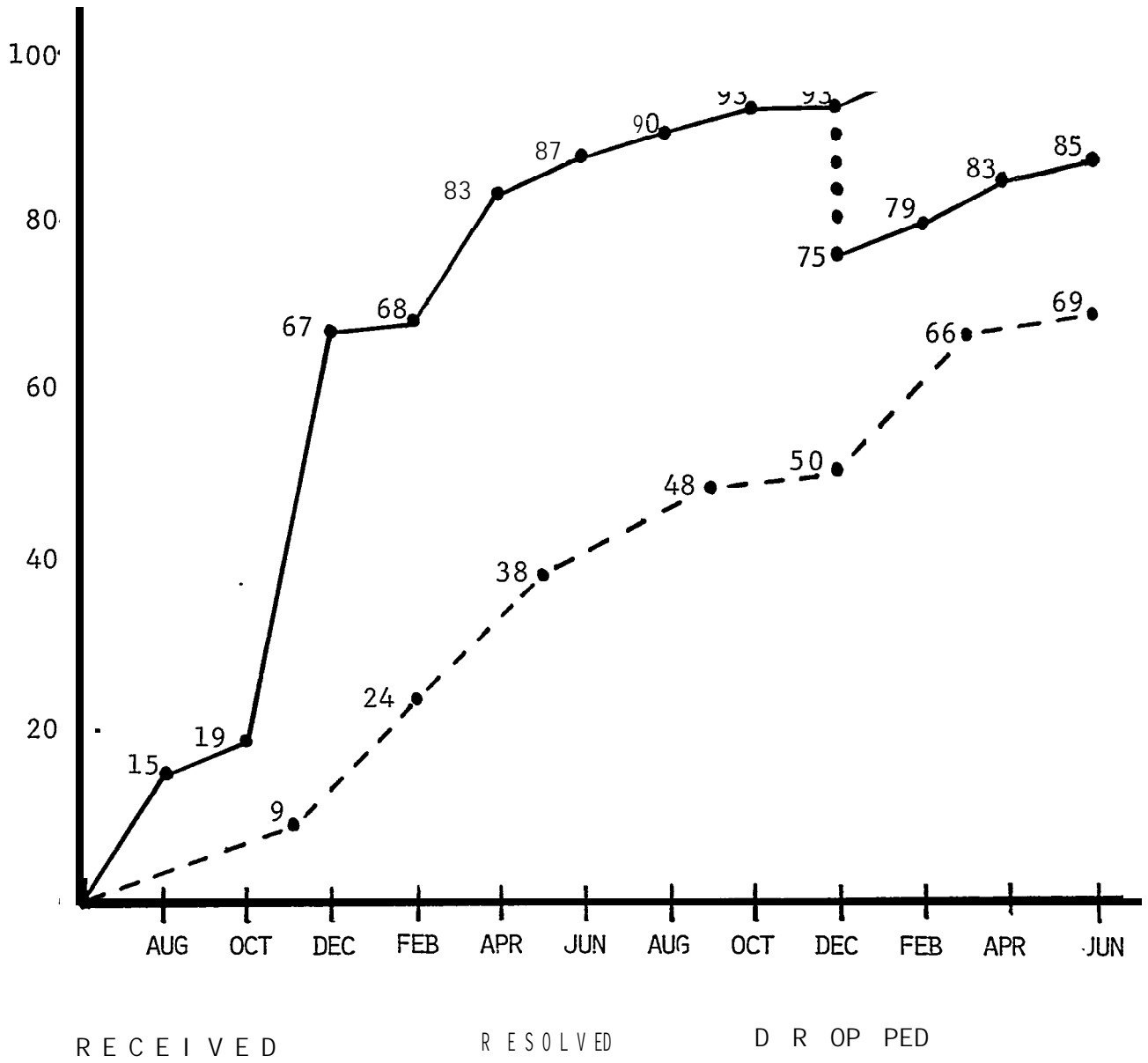
<u>MODULE</u>	<u>VERSIONS</u>		
	<u>BASE</u>	<b>"A"</b>	<b>"B"</b>
AUTOBASE	1	3	4
GENPUR	3	5, 1	5, 1
FAI R	3	4, 1	4, 2
DRAW	3	3	4, 1
TRABO	2	5	6
MI SC	1	1	1
DUP	1	2	3
SHELL	2	2	6
TEMPLATE	2	2	2
LANSKI	1	1	1, 1
PRODA	1	1	1
ALKON	3	9, 1	10, 1
NEST	2	2	4
ALKNES	<b>1</b>	1, 1	1, 1

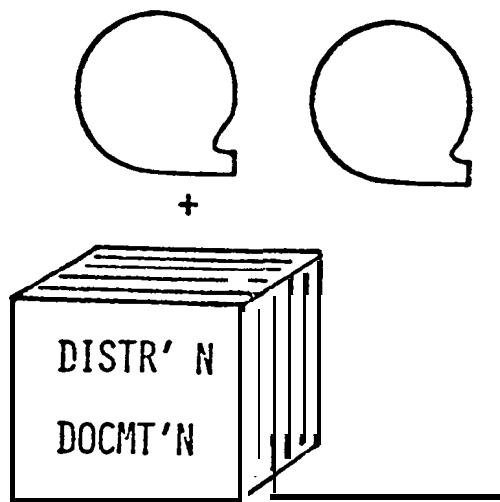
SUPPORTED AUTOKON VERSIONS

## HOW MODIFICATIONS ORIGINATE

- REAPS ANALYSIS REQUEST ACTIVITY
- SRS MAINTENANCE CENTRAL ACTIVITY

# A R ACTIVITY '74-'76





- SYS TAPES

- BASE - vs "B" VERSION

- EXPLAIN UPDATES

- IMPL'N PROC

- ACC TESTS

<u>MODULE</u>	<u>LEVEL</u>
(*) AUTOBASE	4
GENPUR	5, 1
*FAIR	4, 2
*DRAW	4, 1
*TRABO	6
MI SC	1
*DUP	3
*SHELL	6
TEMPLATE	2
*LANSKI	1, 1
PRODA	<b>1</b>
*ALKON	<b>10.1</b>
*NEST	4
ALKNES	1, 1

VERSION "B"

(\*) UPDATED SERVICE MODULE

\* UPDATED MODULE .



- FAIR

E-FILE PRINT SUMMARY

- RESTORE MISSING SUBROUTINE ARGUMENT

# E-FILE SUMMARY

E-TAPE SUMMARY PROGRAM FOR FRAME OFFSET OF

.00 AND INTERNAL UNITS CONVERSION FACTOR

304.80

## POSITION TABLES RECORD, FRAMES

USER NO.	-800.00	POSITION#	-16.01
USER NO.	-700.00	POSITION#	-14.01
USER NO.	-600.00	POSITION#	-12.01
USER NO.	-500.00	POSITION#	-10.00
USER NO.	-400.00	POSITION#	-8.00
USER NO.	-300.00	POSITION#	-6.00
USER NO.	-200.00	POSITION#	-4.00
USER NO.	-100.00	POSITION#	-2.00
USER NO.	.00	POSITION#	.00
USER NO.	100.00	POSITION#	2.00
USER NO.	200.00	POSITION#	4.00
USER NO.	300.00	POSITION#	6.00
USER NO.	400.00	POSITION#	8.00
USER NO.	500.00	POSITION#	10.00
USER NO.	600.00	POSITION#	12.01
USER NO.	700.00	POSITION#	14.01
USER NO.	800.00	POSITION#	16.01
USER NO.	900.00	POSITION#	18.01
USER NO.	1000.00	POSITION#	20.01
USER NO.	1100.00	POSITION#	22.01
USER NO.	1200.00	POSITION#	24.01
USER NO.	1300.00	POSITION#	26.01
USER NO.	1400.00	POSITION#	28.01
USER NO.	1500.00	POSITION#	30.01
USER NO.	1600.00	POSITION#	32.00
USER NO.	1700.00	POSITION#	35.59
USER NO.	1800.00	POSITION#	38.38
USER NO.	1900.00	POSITION#	41.17
USER NO.	2000.00	POSITION#	43.96
USER NO.	2100.00	POSITION#	46.75
USER NO.	2200.00	POSITION#	49.54
USER NO.	2300.00	POSITION#	52.33
USER NO.	2400.00	POSITION#	55.12
USER NO.	2500.00	POSITION#	57.90
USER NO.	2600.00	POSITION#	60.69
USER NO.	2700.00	POSITION#	63.48
USER NO.	2800.00	POSITION#	66.27
USER NO.	2900.00	POSITION#	69.06
USER NO.	3000.00	POSITION#	71.85
USER NO.	3100.00	POSITION#	74.64
USER NO.	3200.00	POSITION#	77.43
USER NO.	3300.00	POSITION#	80.22
USER NO.	3400.00	POSITION#	83.01
USER NO.	3500.00	POSITION#	85.79
USER NO.	3600.00	POSITION#	88.58
USER NO.	3700.00	POSITION#	91.37
USER NO.	3800.00	POSITION#	94.16
USER NO.	3900.00	POSITION#	96.95
USER NO.	400.00	POSITION#	99.74
USER NO.	4100.00	POSITION#	102.53
USER NO.	4200.00	POSITION#	105.32

# E-FILE SUMMARY

FRAME NO. 6.00, POSITION=	12.01, 2 STRAIGHT LINE ELEMENTS,	8 CIRCULAR ELEMENTS,	0 INFLECTION POINTS
FRAME NO. 7.00, POSITION=	14.01, 2 STRAIGHT LINE ELEMENTS,	9 CIRCULAR ELEMENTS,	1 INFLECTION POINTS
INFLECTION POINTS... ( 4,	5.84, 34.45) (		
FRAME NO. 8.00, POSITION=	16.01, 1 STRAIGHT LINE ELEMENTS,	10 CIRCULAR ELEMENTS,	1 INFLECTION POINTS
INFLECTION POINTS... ( 3,	6.63, 34.45) (		
FRAME NO. 9.00, POSITION=	18.01, 6 STRAIGHT LINE ELEMENTS,	11 CIRCULAR ELEMENTS,	1 INFLECTION POINTS
INFLECTION POINTS... ( 8,	7.42, 34.45) (		
FRAME NO. 10.00, POSITION=	20.01, 5 STRAIGHT LINE ELEMENTS,	18 CIRCULAR ELEMENTS,	1 INFLECTION POINTS
INFLECTION POINTS... ( 13,	5.53, 32.01) (		
FRAME NO. 11.00, POSITION=	22.01, 5 STRAIGHT LINE ELEMENTS,	21 CIRCULAR ELEMENTS,	3 INFLECTION POINTS
INFLECTION POINTS... ( 3,	.36, 7.58) ( 8, .95, 15.58)	( 17, 6.35, 32.01)	(
FRAME NO. 12.00, POSITION=	24.01, 1 STRAIGHT LINE ELEMENTS,	26 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 9,	1.33, 17.23) ( 18, 7.16, 32.00)		(
FRAME NO. 13.00, POSITION=	26.01, 0 STRAIGHT LINE ELEMENTS,	25 CIRCULAR ELEMENTS,	4 INFLECTION POINTS
INFLECTION POINTS... ( 2,	.13, .00) ( 3, .71, 2.46)	( 9, 2.07, 17.24)	( 16, 7.97, 32.00)
FRAME NO. 14.00, POSITION=	28.01, 0 STRAIGHT LINE ELEMENTS,	25 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 9,	2.82, 17.24) ( 17, 11.36, 34.45)		(
FRAME NO. 15.00, POSITION=	30.01, 0 STRAIGHT LINE ELEMENTS,	27 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 10,	3.58, 17.24) ( 18, 12.14, 34.45)		(
FRAME NO. 16.00, POSITION=	32.80, 0 STRAIGHT LINE ELEMENTS,	27 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 9,	4.72, 15.58) ( 18, 13.23, 34.45)		(
FRAME NO. 17.00, POSITION=	35.59, 0 STRAIGHT LINE ELEMENTS,	25 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 8,	5.74, 14.76) ( 17, 17.57, 37.73)		(
FRAME NO. 18.00, POSITION=	38.38, 0 STRAIGHT LINE ELEMENTS,	25 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 9,	6.75, 14.77) ( 18, 18.57, 37.73)		(
FRAME NO. 19.00, POSITION=	41.17, 0 STRAIGHT LINE ELEMENTS,	25 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 9,	7.77, 14.77) ( 17, 19.58, 37.74)		(
FRAME NO. 20.00, POSITION=	43.96, 2 STRAIGHT LINE ELEMENTS,	26 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 11,	8.66, 11.47) ( 21, 23.26, 40.44)		(
FRAME NO. 21.00, POSITION=	46.75, 2 STRAIGHT LINE ELEMENTS,	25 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 11,	9.64, 11.47) ( 20, 24.26, 40.44)		(
FRAME NO. 22.00, POSITION=	49.54, 2 STRAIGHT LINE ELEMENTS,	24 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 11,	10.63, 11.47) ( 19, 25.26, 40.44)		(
FRAME NO. 23.00, POSITION=	52.33, 2 STRAIGHT LINE ELEMENTS,	24 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 11,	11.62, 11.47) ( 19, 26.25, 40.44)		(
FRAME NO. 24.00, POSITION=	55.12, 2 STRAIGHT LINE ELEMENTS,	23 CIRCULAR ELEMENTS,	2 INFLECTION POINTS
INFLECTION POINTS... ( 10,	12.59, 11.48) ( 18, 27.24, 40.45)		(
FRAME NO. 25.00, POSITION=	57.90, 2 STRAIGHT LINE ELEMENTS,	23 CIRCULAR ELEMENTS,	2 INFLECTION POINTS

- ALKON ENHANCE
  - USER GEO TRACE
  - CONTROL PASS2 EXEC
  - NEW VOC WORDS
  - OVERLENGTH CALCULATIONS
  - VECTOR OPERATIONS
  - FIX BUGS

## ALKON GEO DUMP/TRACE

### Ž DUMPS GEOMETRY AREA

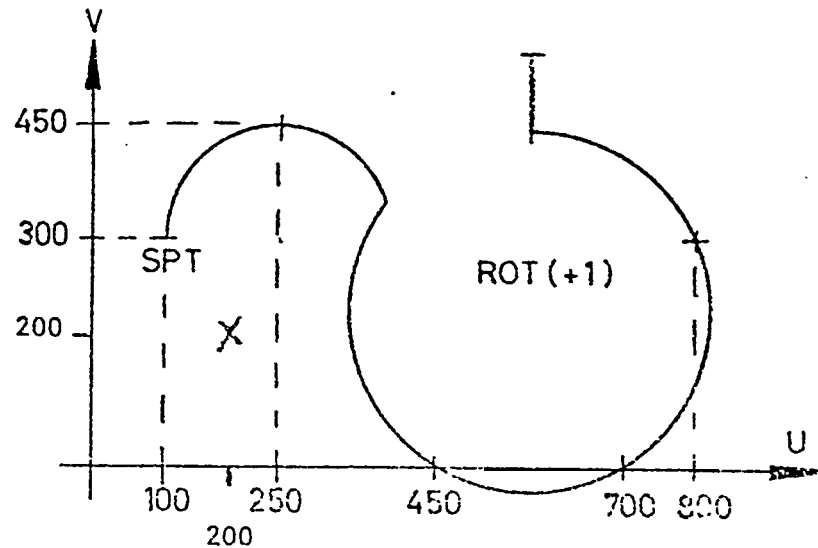
- WHEN ERROR OCCURS
  - AT USER REQUEST
- 
- EASY TO READ

## USER TRACE

```

1,  ?
2,  TEMP'  STRT RGEO'  ON(CT)
3,  SPT  (+100+300)
4,  CIR:  SDIR(+90)  PT(+250+450)  INT(+400+700)
5,  CIR:  PT(+700+0)  PT(+300+300)  PT(+450+0)  EDIR(+130)  ROT(+1)
6,  SL:  DIR(+90)  LGTH  (+50)
7,  SL:  PT(+200+200)
8,  END RGEO'  PRINTCON'

```



\*\*\*DUMP OF ESA\*\*\*

```

STRT:  EPT( 100, 0+ 300, 0)
CIR:    EQU ( 250, 0+ 300 , 0+  -150, 0)  SPT( 100, 0+ 300, 0)
        EPT( 386, 7+ 361, 8)
CIR:    EQU ( 575, 0+ 208, 3+  243 , 0)  SPT( 386, 7+ 361, 8)
        EPT( 575, 0+ 451, 3)
SL:     EQU (   1, 0+   , 0+  -575, 0)  SPT( 575, 0+ 451, 3)
        EPT( 575, 0+ 501, 3)
SL:     EQU (   -, 6+   -, 8+  -30, 6)  SPT( 575, 0+ 501, 3)
ERROR 364( 0          0          0) OCCURRED ON LINE 8 IN MANUS 3

```

# ALKON GEO TRACE

```

1, ?
2, STRT LGEO'
3, SPT (+800, +0, ) ON(CT)
4, CIR: CNT(+0, +0, ) RAD(+8000) EDI R(-90)
5, CIR: CNT(+0, +0, ) RAD(+800) EDI R(+99) OFF(CT)
6, END LGEO'

```

\*\*\*DUMP OF ESA\*\*\*

```

STRT:
STRT:
STRT:
STRT:
STRT: EPT(800, +0, )

```

\*\*\*DUMP OF ESA\*\*\*

```

STRT:
STRT:
STRT: EPT(800, +0, )
CIR: SPT(800, +0, ) EDR(-90, ) CNT(0, 0, )
      RAD(800, ) ROT(800# )

```

\*\*\*DUMP OF ESA\*\*\*

```

STRT:
STRT:
STRT:
STRT: EPT(800, +0, )
CIR: EQU(0, +0, +800, ) SPT(800, +0, ) EPT(-800, +0, )

```

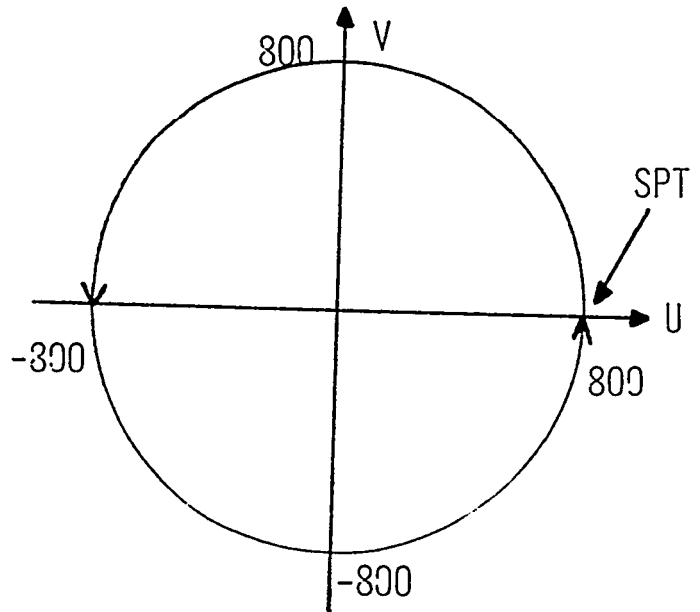
•

\*\*\*DUMP OF ESA\*\*\*

```

STRT:
STRT:
STRT: EPT(800, +0)
CIR: EQU(0, +0, +800, ) SPT(800, +0, ) EPT(-800, +0, )
CIR: EQU(0, +0, +800, ) SPT(-800, +0, ) EPT(800, +0, )

```



## ERROR CONTROL

- OPTION Y
  - COMPILE ONLY
  - COMPILE AND EXECUTE ALKON
  - COMPILE AND EXECUTE IF NO ERRORS
- ERROR
  - USER GENERATES ERROR MESSAGE
- ABORT
  - USER ABORTS MANUSCRIPT



# ERROR CONTROL

EX:

?

%Y1'

—

—

STRT RGEO'

SPT (A1 + A2)

SL: DIR (90, )

TEST 0, 1 (A3)

ERROR 999' ABORT'

LAB1: LGTH (A3)

ALKON

NC OUTPUT CONTROL

Ž ON (IGNORE)

- OFF (IGNORE)

VECTOR OPS

- DOT ALIST (BLIST)
- CROSS ALIST, BLIST (CLIST)
- NORML ALIST (BLIST)
- Ž VADD ALIST, BLIST (CLIST)
- VSUB ALIST, BLIST (CLIST)

ALKON

OVERLENGTH ALIST (BLIST)

CALC:

- WEB OVERLENGTH
- FLANGE OVERLENGTH
- ANGLE BTWN WEB/FLANGE

ALKON BUGS

Ž TXTHEIGHT

- %K %L

Ž BUFFER STAT

Ž MATRIX NAME

ALKON

## DRAW BUGS

### Ž DRAW SPACE CURVES

- TIC MARKS
- GRID & WNDW
- TRIMMING

## BUGS CORRECTED:

AUTOBASE                      LANSKI

TRABO                         SHELL

DUP                            NEST

DOCUMENTATION

- NEW LANSKI

- Ž UPD ALKON HANDBOOK

- Ž UPD ALKON PROG GUIDE

- UPD DUP

- Ž UPD MISC

## SIMPLIFIED ALKON

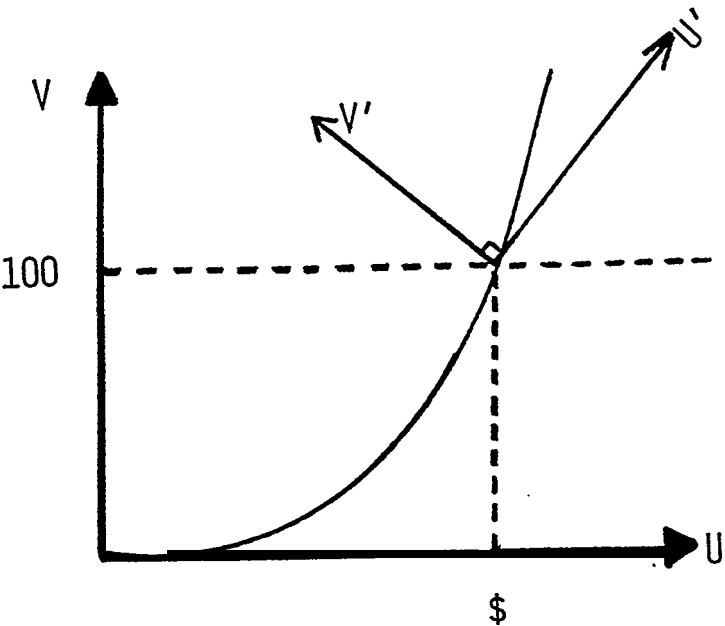
- DESCRIBE SINGLE PART
- REF LCON, ACON, PCON
- STORE PART
- LIMITED TEXT, DRAW OUTPUT
- NORMS, REPS OK
- FULL GEOMETRY SPECS
- SAME DATABASE

SIMPLIFIED ALKON	ALKON
TFR N '	TFRAME N' AT SHELL' FETCH LCON'' FETCH LTAB'
COPACON'	STRT TAB RBUF(+5+2) (CONMO) GENTAB 11 (1+LINES(ABUF)+ ABUF +2+0) END TAB RBUF (CONMO)
ACON	CON ABUF
LCON	CON LBUF
LONG N '	INLONG (N+ RBUF+ELIST)

Ž MISSING COORDINATE

LCON

AXIS (+\$+100, +\$)



## Ž IMPLIED DO-LOOP

AXIS 1, 1,B5,2 (+ARG+ARG...)

---

DO 10 (+1+B5+2)

AXIS 1 (+ARG+ARG+ , , , )

LAB 10:

## NORMS ENHANCEMENTS

- 33 NORMS CHANGED
- 4 ADDED

Ž 3 DELETED

Ž TECH NOTE PUBLISHED



STUDY FOR THE IMPROVEMENT OF MOTIVATION  
IN THE SHIPBUILDING INDUSTRY

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As a Professor at San Jose State University, Dr. Muench is currently involved in teaching, clinical and consulting practice, and research in clinical and industrial psychology. He has held an impressive array of teaching, research, administrative and consulting positions in government and private organizations.

This study is intended to be read in its entirety. The results of the study develop optimum significance and meaning when perceived within the emergent process of the research. The first chapter introduces the study in terms of its purposes and procedures. The next chapter surveys the general literature pertinent to motivation industry organized according to the research plan of this study. The next chapter reports in depth the results from the current study, including composite data for the total industry, as well as a brief comparison of ten separate local shipyards.

Although executives involved in the decision-making process in the industry would be well advised to read the entire study, many executive would find such reading to be a luxury prohibited by other critical time commitments. Therefore, the primary results of the study have been **summarized in terms of pertinent conclusions and recommendations** for the immediate utilization by the interested but busy executive.

#### Executive Summary

One of the most significant motivating factors for workers is to believe that the company management is interested in the individual worker and his problems and is willing to attempt to do something about them. Although a limited understanding of workers' needs may be obtained from the research literature on worker motivation, since workers are unique, the only way to really understand the workers' needs in a particular

industry or particular company is to directly ask the individual local workers. Further, even the process of attempting to determine the worker's needs and problems is motivating, since it tends to help the worker to feel that the company cares enough to ask him. Those responsible for initiating this study, then, have taken a significant first step in improving motivation.

Since motivation in industry is a complex phenomenon, for the purpose of this study motivation has been analyzed in terms of relationships to' some of its various segments beginning with job satisfaction, the core factor around which all the other dimensions of the motivational process would evolve. The factors, in addition to job satisfaction include job commitment and morale, job importance, working conditions and benefits, workers' perceptions of co-workers, promotion, and supervisor-worker relationships.

The body of the report is organized around the aforementioned categories and the results are reported accordingly. For the purpose of this summary, however, an attempt is made to utilize the direct data from this study interrelated with other research data to present some conclusions and recommendations which are aimed toward developing a more effective motivational system at the local shipyard level. These conclusions relate mainly to the quantitative data and are presented, not in terms of priority importance, but in sequential order.

1. Nearly 1,300 employees, representing all segments of personnel at ten shipyards, were utilized for this study. From this total sample, only a small percentage of workers chose shipbuilding because of a love of the sea, or family tradition, or patriotic reasons; most workers took a job at a shipyard primarily because a job was available. There tends to be no more romantic worker identification with obtaining a job in a shipyard than in comparable industries.

2. While recognizing the validity of the above finding, there is another finding which relates to work pride regarding both product and process. Nearly all shipyard workers deem both shipbuilding as an industry and their own job in the process of shipbuilding to be essential for the national defense, economy and commerce of this country. This product identification has not been sufficiently emphasized at most shipyards. Employee pride related to product is, if effectively utilized, an inherent motivator.

3. Current literature tends to indicate that the industrial worker in America is Unhappy with his job. The interviewers for this study expended most of their interview time in listening to worker complaints and negative comments related to both job and company. When a final evaluation needed to be made, however, most workers tended to rate their overall job satisfaction high and, at least at America's shipyards, had a high level of job identification.

4. Worker motivation tends to increase when jobs are designed to provide the worker with what he perceives to be

meaningful work. When his job allows the worker to feel personally responsible for a meaningful portion of his work, and provides results which are perceived as worthwhile to the individual worker, motivation increases. Further, the job must match the capabilities and skills of the employee. If a job is too frustrating or difficult, or too simple and boring, motivation decreases. To effectively match the employee to his job requires continual evaluation of each job and the employee qualities necessary to fulfill it.

5. Although most shipyard workers believe their job in an essential industry to be highly important, many believe that their company's management has no interest in them as persons, is unaware of what they do, and is oriented to machines rather than persons.

6. Most hourly production workers believe that they do not influence the company in any important ways. The fewer than twenty percent of the workers who believe their influence is important perceive that influence to come primarily in the way they perform their own job. The majority of workers who believe that they cannot influence the company in important ways cited that it was futile to try, that the company didn't care or was too big or set in its ways, or that their low position or lack of knowledge prohibited their influence.

7. The most common spontaneous complaint **among production** workers which is related to working conditions **concerned**

inadequate scheduling, planning, coordinating and communication between crafts, shifts and various working groups in the shipyard. The second greatest number of complaints related to inadequate machines, equipment and materials. The third most common complaint concerned some aspect of the physical working environment.

8. Safety was the physical factor most frequently discussed by the workers and, although all were concerned with safety, about as many believed the company to be safety conscious and working on improving safety conditions as believed the yard to be negligent related to safety. Safety was considered a greater problem to hourly production workers than any other employee group.

9. The workers' perceptions of the adequacy of their wages produced a mixed result. Some workers believed the pay to be superior to that in some comparable industries; others believed their pay to be low and not comparable to other companies or construction workers. Wages tended to be less a problem, however, to most workers than problems already cited.

10. Wages become increasingly motivating when workers perceive that their pay is directly related to their performance. Oftentimes pay is related to non-performance factors such as job level or seniority and, therefore, comparatively less motivating. Consequently, some companies have elected to use some incentive system to tie wages more closely to production. Normally most incentive systems indicate greater success by

relating to an individual, rather than group, performance. The experience of at least one shipyard suggests some evidence to the contrary. Although the incentive pay tied to the individual's work performance has been normally most motivating, more experimentation needs to be done with group incentive programs in order to determine whether the group incentive, when effectively organized, may prove additionally motivating due to group identification or group pressures not present in individual incentive plans.

11. If effectively done, measuring a worker's performance can be highly motivating. This means that an effective job measurement system including specific criteria for evaluation must be available in addition to a feedback system which provides the worker with immediate knowledge of results and recognition for superior performance.

12. One of the most important motivational factors is the relationship of the worker to his immediate supervisor. Although it is impossible to define all of the characteristics of the "perfect" supervisor, effective leadership does include the leader's sensitivity to those factors which influences the personal and interpersonal work behavior of group members, the ability to analyze those factors impairing personal or group effectiveness, and the empathy and consideration necessary to individual needs which allow the group to keep moving.

13. The current study indicates that the employee's relationship to his immediate supervisor is a key one, and

for a Significant majority, a positive one. Among the positive factors most frequently mentioned about the workers' immediate supervisor include the following: his technical competence, fair treatment, good human relationships, helpful, and freedom to do the job. The negative comments related to the workers' immediate supervisor were fewer and less consistent but included the following: overcritical, shows favoritism, inadequate leader, poor communicator, technically incompetent. For most employees, the relationship with the immediate supervisor tends to be better than the workers' opinion of and relationship with higher management.

14. Feedback at all levels is essential. An employee will tend to improve his performance if he has continuing feedback related to his progress. It is as important for the supervisor at the upper levels of management to give consistent feedback related to performance as it is for the supervisor of the hourly worker. Feedback, both positive and negative, needs to be clearly understood by both supervisor and worker, and presented in a manner which motivates constructive short and long-range changes.

15. Some workers are more motivated when the supervisor gives them a considerable amount of his time while other workers work best with a minimum of supervisor surveillance. For example, the younger workers tend to need and request more attention and direction from their supervisors than do the older, more experienced workers. In fact, sometimes the



older workers consider the supervisory attention more of an interference than a help. However, some workers, no matter their age and experience, need considerable feedback, so that the useful generalization related to age still must be individually applied.

16. Positive reinforcement (commending good performance) is generally considered a superior motivator to negative reinforcement (reproof for poor performance) . Generally the shipyard industry, at all levels of the organization, emphasizes negative rather than positive reinforcement. Some companies in industries other than shipbuilding who have attempted a change from censure to commendation report immediate and, occasionally, miraculous positive results.

17. Although positive reinforcement is generally a superior motivator to negative reinforcement, some employees, normally the most competent ones, may be motivated by reproof rather than commendation, or are self-motivated and need little external motivation. The principle of reinforcement, like every motivation technique, must be applied appropriately to the unique needs of the individual worker. Generally positive reinforcement is the superior motivator but, to be optimally effective, the supervisor must understand his workers well enough to discern which motivational techniques work best for each worker.

18. Some employees are sufficiently motivated by internal satisfactions which come from the employee's own realization

that he has done an effective or superior job. Most workers, however, in addition to internal satisfaction, also need external recognition. Merit salary increases, promotions and increased responsibility and recognition are common and effective ways to acknowledge deserving performance. Since such recognition is not always possible, these means may need to be supplemented by a recognition system which provides other kinds of rewards or awards to individuals or groups for exceptional performance.

19. Employees at all levels of the shipyard tend to have a high regard for their co-workers, including both technical competence and positive interpersonal relationships. This "finding was one of the most consistent and significant results from the study.

20. Only about one-half of the hourly production workers, however, believe that the majority of their co-workers worked sufficiently hard to do the job although, generally, the closer the proximity of the worker, the harder he was perceived to work. That is, most workers indicate that they work harder than their immediate peers, who work harder than workers in other related departments, who work harder than workers in most departments more distant from the workers' station.

21. In comparing production managers to hourly production workers, the conclusions are as follows: production managers have higher job satisfaction, enjoy their jobs more, identify more with the company; have higher morale, perceive that they

have a greater influence at the company, believe that their problems and recommendations get greater action, are more satisfied with wages and benefits with the exception of longer unpaid working hours, believe safety conditions to be better, and have a greater desire to be promoted, have a higher expectation of being promoted, and think more highly of the promotion process.

22. Much experimentation has occurred with participative management or participative decision-making as a motivational concept. Most studies, both within and without the ship-building industry, indicate that participative decision-making normally results in increased motivation and productivity of those involved. When the worker participates in making decisions which effect him, he is more likely to be motivated to make those decisions succeed. The success is greater when the employees possess high competence and high needs for independence and are members of a group that favor participation. The quality of the group decisions are enhanced when the employees have sufficient relative information and time for discussion, and when employee self-interests do not conflict with the group interests.

23. Effective communication within a company demands constant vigilance. Every shipyard represented in this study suffered from communication problems, some severe. It may be impossible to eliminate all problems of communication within an organization but much can be done to improve communication. First, there must be a genuine desire to communicate at the

various levels of the organization. Second, communication must be recognized as multi-dimensional with attention given to horizontal as well as two-way vertical communication. This means that effective communication channels need to be found to transmit information from management to employees and, an area frequently ignored, from the employees to management. Formal means of communication, such as company newspapers, closed-circuit television, employee suggestion systems, attitude measurement programs and the like, need to be supplemented by more human contacts of management and workers. This is difficult in large organizations, but some companies find that when top management gets out of the confines of their administrators' offices and has direct personal contact with the workers through plant tours, informal talks, etc. that both communication and motivation improve.

24. Contrary to certain research hypotheses held prior to this study which presupposed a less than healthy shipbuilding industry, the results of this study are encouraging in that many more strengths than weaknesses are apparent at most shipyards. This does not mean that serious motivational problems do not exist. It does mean that for most yards the strengths portend both the ability and the motivation to recognize weaknesses and attempt to alleviate them. An attempt has been made in this report to crystallize inter-company and intra-company comparisons according to the factors utilized in this study. Hopefully these data may be used as the foundation to develop programs at the local yards aimed at perfecting the motivational processes.

SPARDIS--A SHIPYARD PRODUCTION  
AND CONTROL SYSTEM

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## INTRODUCTION

SPARDIS provides NASSCO with a tool to use one of its most valuable resources - information. SPARDIS is designed to provide various levels of management with the information they need to better perform their function. It is intended that the task of providing this information be accomplished with the least amount of paper work. To do this, all of the SPARDIS information is in the form of on-line, real time, data inquiry and update. Data is collected, updated and maintained for the system through a network of communications terminals. These terminals are located where data is originated, the system user area. The communications terminals are located throughout the shipyard at strategic locations for both inquiry and update. Responsibility for data input is placed in the area organizationally responsible for its creation and maintenance. The teleprocessing system permits decisions to be made based on the latest information available. As a management tool for planning and scheduling SPARDIS provides:

- .Explicit Schedule and instructions to make parts, assemble components install. equipment, etc.

- .Management reports including:

- Status of items in the manufacturing cycle
- Work behind schedule
- Progress to date against the schedule
- Status of inventory items needed
- Definition of future work

- **Projection of material requirements.**
- Consolidation of work load by operation.
- **Control of the in-process inventories.**
- **A consistent part-task identification method.**
- Engineering progress record.

## I SPARDIS

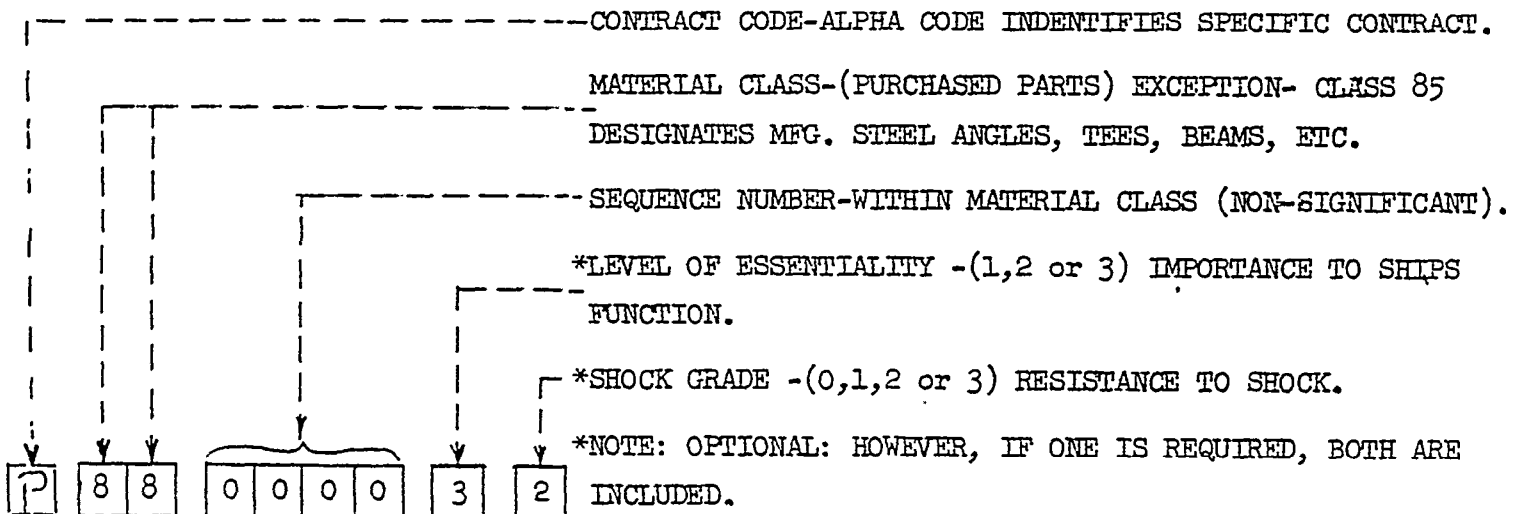
SPARDIS is an acronym for Scheduling Planning And Reporting Data Information System. It is a tool designed to assist in the scheduling and planning associated with the construction of ships. The system is designed to permit visibility of this planning at various levels. It permits a high level overview as to the status of large sections of the ship as well as visibility down to the smallest part.

SPARDIS is designed to use a numbering system as the key to the information base. This numbering system is used throughout the shipyard so that a number assigned to a part is the same number used by Engineering, Material, and Production. The number associated with a part becomes its **name and this name is always used to identify the part. There are two basic classes of numbers used in SPARDIS. One is the Material Code Number which is the number used to identify raw stock. The other is the Manufactured Piece Number.**

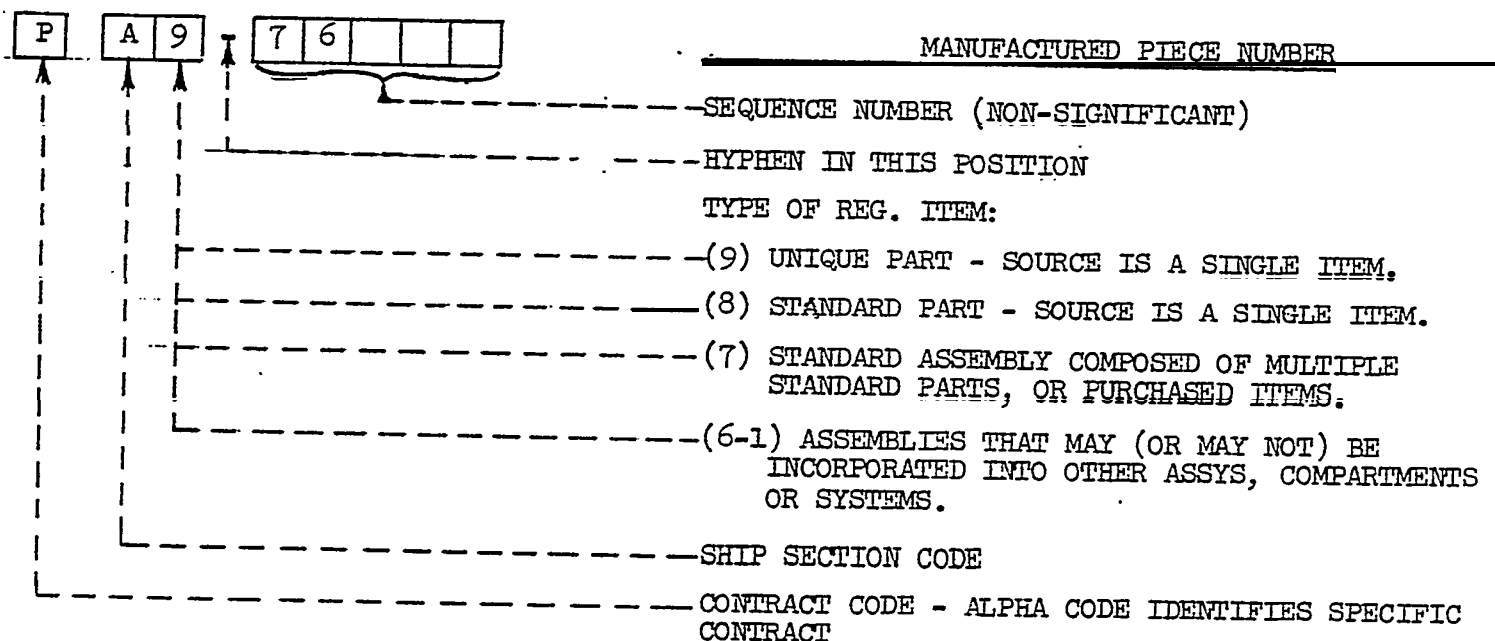
Except for the contract code assigned, the Material Code Number is completely numeric. It takes the form of either six or eight numeric digits. The first two characters indicate the material class (e.g. 01 is Pipe, 82 Steel, etc. ) The next four characters indicate the specific commodity and size. If present, the last two digits represent the level of essentiality and shock grade.

### MATERIAL CODE NUMBER

#### FOR PURCHASED PARTS



The other numbering format is for the manufactured Piece Number. This is distinguished from the Material code Number by the presence of an alphabetical letter in the first position following the contract code. The rest of the characters are always numeric. The first position, which is alphabetic, denotes in which Ship Section or general area of the ship the item is used. The second position, which is numeric, denotes the level of importance to the parent assembly or task. The remaining characters of the piece number are filled first with a hyphen for consistent spacing, and a series of from one to five numeric characters. These numeric characters to the right of the hyphen, bear no significance to the part number, except that they tend to be sequentially assigned. Thus they are termed "non-significant but sequential". In order to separate part and assembly numbers pertaining to one group of ships from numbers designated for another group, an alpha-character has been imposed preceding the first position of the piece number. SPARDIS further analyzes a piece number by distinguishing parts from assemblies and tasks by use of the piece numbering system. A part (being an item which is fabricated exclusively from a single source item) is designated by either a number "8" or "9" found in the "level" position of the part number. An assembly (being the joining in some manner of two or more parts) is designated by the number 7 thru 1 depending on the level of structure it is on the ship. SPARDIS says "the smaller the number in the 'level' position of an item number, the greater significance this item has in the total structure." For example, an A6 assembly, is of greater significance than an A8 part, and an A3 assembly, is of greater significance than the A6 assembly and so on. The ship section codes and the "level" indicators are described further on the following pages.





# NASSCO MANUFACTURED PART NUMBERING SYSTEM

## Ship Section Identification:

All part, assembly, system, compartment, task and event numbers are prefixed with an alphabetical character to indicate the appropriate group within Engineering or Production planning responsible for their assignment. The ship section numbers are as follows:

<u>ALPHA CHARACTER</u>	<u>RESPONSIBLE GROUP</u>	<u>DESCRIPTION</u>
A	HULL ENGINEERING	HULL STRUCTURE
B	HULL ENGINEERING	FOUNDATIONS
c	HULL ENGINEERING	HULL FITTINGS
D	HULL ENGINEERING	CARPENTRY
E	(OPEN)	(OPEN)
F	(OPEN)	(OPEN)
G	HULL ENGINEERING	RIGGING
H	HULL ENGINEERING	SCIENTIFIC (WAYS)
J	(OPEN)	(OPEN)
K	ELEC. ENGINEERING	POWER & LIGHTING
L	(OPEN)	(OPEN)
M	ELEC. ENGINEERING	ELECTRICAL STANDARDS
N	ELEC. ENGINEERING	ELECTRICAL
Q	PROD. PLANNING	NASSCO STANDARD PARTS ( ALL SHIPS ALL CONTRACTS)
P	MACHINERY ENGINEERING	PIPING
R	MACHINERY ENGINEERING	VMACHINERY
S	MACHINERY ENGINEERING	MACHINERY
T	MACHINERY ENGINEERING	MACHINERY
V	MACHINERY ENGINEERING	VENTILATION
w	MACHINERY ENGINEERING	SPEC. ITEMS
	PROD. PLANNING	
x	PROD. PLANNING	COMPARTMENTATION,
Y	PROD. PLANNING	MAJOR TASK/ EVENT COMPARTMENTATION
Z	(OPEN)	(OPEN)

### Manufacturing "Level" Numbers:

The "level" indicator denotes the level of importance to the parent assembly or task, not necessarily its position in the network. The manufacturing 'level" indicators are as follows:

<u>LEVEL</u>	<u>ASSIGNEE</u>	<u>DESCREPTION</u>
1	PRODUCTION <b>PLANNING</b>	A SPECIFIC TASK OR EVENT, AREA OF THE SHIP, OR SYSTEM NUMBER
2	PRODUCTION	A UNIQUE ERECTION ASSEMBLY CONSISTING OF TWO OR MORE PARTS AND/OR TWO OR MORE <b>6, 5, 4, OR 3</b> LEVEL ASSEMBLIES THAT ERECT DIRECTLY INTO THE <b>HULL</b>
3	PRODUCTION <b>PLANNING</b>	A UNIQUE ASSEMBLY CONSISTING OF TWO OR MORE PARTS AND/OR TWO OR MORE <b>6, 5, 4, OR 3</b> LEVEL ASSEMBLIES THAT NEXT ASSEMBLE INTO ANOTHER ( <b>3</b> or 2 LEVEL) ASSEMBLY.
4	PRODUCTION <b>PLANNING</b>	A UNIQUE ASSEMBLY CONSISTING OF TWO OR MORE PARTS AND/OR TWO OR MORE <b>6, 5, OR 4</b> LEVEL ASSEMBLIES THAT NEXT ASSEMBLE INTO ANOTHER ( <b>4,3, OR 2</b> LEVEL) ASSEMBLY.
5	PRODUCTION PLANNING	A UNIQUE ASSEMBLY CONSISTING OF TWO OR MORE PARTS AND/OR TWO OR MORE <b>6</b> OR <b>5</b> LEVEL ASSEMBLIES THAT NEXT ASSEMBLE INTO ANOTHER ( <b>5, 4, 3, OR 2</b> LEVEL) ASSEMBLY.
6	PRODUCTION <b>PLANNING</b>	A UNIQUE ASSEMBLY CONSISTING OF TWO OR PARTS THAT NEXT ASSEMBLE INTO ANOTHER ( <b>6, 5, 4, 3, OR 2</b> LEVEL) ASSEMBLY.
7	ENGINEERING - PRODUCTION	A STANDARD MINUFACTURED ASSEMBLY HAVING SUFFICIENT REQUIREMENTS TO JUSTIFY STANDARDIZATION AND BATCH-MANUFACTURE. COMPLETE INTERCHANGEABILITY IS MANDATORY.
8	ENGINEERING	A STANDARD MANUFACTURED PART HAVING STANDARDIZATION AND BATCH-MANUFACTURE. COMPLETE INTERCHANGEABILITY IS MANDATORY.
9	ENGINEERING	A UNIQUE MANUFACTURED PART HAVING A LIMITED REQUIREMNT TO THE EXTENT THAT A STANDARD CANNOT BE JUSTIFIED.

## STANDARD PARTS & ASSEMBLIES

An 8 "level" part in the SPARDIS System is defined as:

"A standard manufactured part having  
standardization and batch-manufacture.  
Complete interchangeability is mandatory."

Similarly a 7 "level" assembly is defined as:

"A standard manufactured assembly having  
sufficient requirements to justify  
standardization and batch-manufacture.  
Complete interchangeability is mandatory."

The intent of the 7 & 8 "levels" in the SPARDIS numbering system is to account for those parts and assemblies that are used in sufficient quantity that it is economical to batch manufacture them. Confusion often arises due to the many interpretations possible for the term "batch manufacture". Let us examine some of the criteria which must be considered-for something that is to be "batch manufactured" in an attempt to clarify some of this confusion.

One of the first things to consider is that an item, in order to be considered a standard, must be relatively small. This is true because we want to handle the material in groups of parts rather than one-at-a-time. Therefore one of the things we must consider is the ability to handle the material economically.

Complete interchangeability is also required because we want to be able to manufacture a group of these parts for inventory and withdraw them as necessary for use. Another thing to consider then is the set-up time to manufacture certain items. Let us take, as an-example, a ladder which requires a jig to be set-up. It is more economical to make several ladders at one time with one set-up than to **set up the jig everytime a ladder is required. Assemblies such as ladders are not the only items to consider for set-up time. Any part that requires a template could be considered in this category. Every time a part is manufactured that requires a template, someone has to locate the template, bring it to the material, lay it out, and then produce the part. If this is done several times with a single template the cost will be correspondingly high. Therefore set-up time does become part of our criteria.**

Let us discuss a part of the criteria which has produced much confusion and attempt to clarify it. How do we determine, based on the number of parts required, what we should classify as a standard? If a part or assembly is used only once on a hull, it is, by definition, unique and therefore cannot be considered for a standard. We might be tempted to say that if a part is used more than once it should be a standard. This might make the decision process quite simple, but it would not be adequate for production needs. We must first determine if the two or more parts are used in more than one assembly. For example, let us assume that we require ten flat bar stiffeners for a foundation. Let us further assume that these flat bar stiffeners are all identical and are only used in this one foundation. In this case since there is only one demand for the parts, the foundation, we would consider these stiffeners unique. This is true because they will be totally consumed on one assembly. If, however, the same ten stiffeners were used in more than one assembly, let's assume five in one foundation and five in another, we would consider these stiffeners standard parts. We have, then, derived another part of our criteria. In order for a part to be considered a standard it must be used in more than one assembly on a hull.

Using the criteria we have developed we can now formulate several questions which can be used to test a given part to see if we should call it a standard.

1. Is the part/assembly small enough to be handled and stored easily?
2. Is there more than one part/assembly required?
3. Are the parts/assemblies used in more than one assembly?
4. Does that set-up time warrant producing more than one at a time?

If the answers to these questions-were all "yes", then we have determined that this part/assembly should be classified a standard.

If we are to be able to produce several parts/assemblies at any given time we will require some knowledge of when we are going to manufacture them and ensure that the raw material is available. We must ensure there is sufficient material on hand to produce our standards in economical groups or lots. In order to do this both Engineering and Planning must be involved. Engineering must determine the total requirements for the standard and their approximate locations so that Planning can determine when to manufacture the standards and in what quantities. This information, once developed, can be used to determine what raw materials are required and when they should be purchased. It is important that total requirements are determined so that we do not over-manufacture a part.

If all of these criteria are used properly "batch manufacturing" can produce significant cost savings to the shipyard.

## 11 MASTER FILES

The information database that defines the plan for the task of putting together the thousands of parts in a ship, is designed to functionally define the elements of that plan. These functional elements are the structure, description, routing and schedule. In fact, SPARDIS has as its base, four master files which allow the proper definition of these elements. Let us examine each of these elements and their associated files and content to better understand how the information is maintained.

The Description File contains the definitions of what the part assembly is. It allows the user to give meaning to the name given to a part. For example:

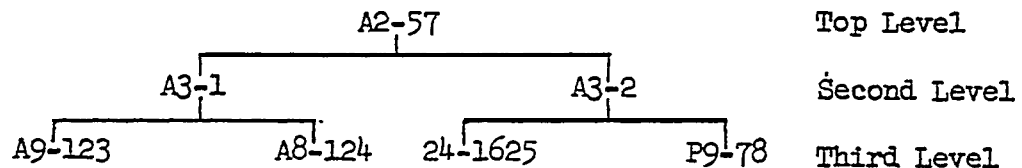
P9-1234 Pipe, Sch 40, 4" X 8' - 0"

The description File can also be used to define a task. For example:

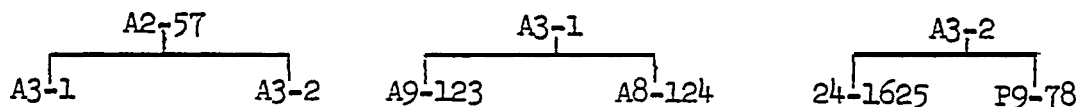
P2-250 Complete installation of innerbottom piping  
fr. 78-85 CL.

In other words the Description File contains the definition of parts, assemblies, or tasks. Each part, assembly or task in the plan is defined in the Description File.

The Structure File defines what pieces are required to go together to produce the next level of assembly. That is, it is a "goes into" type of definition. The Structure File defines what parts, assemblies or tasks go together to form new assembly or task. This type of an arrangement of parts is also known as a hierarchical arrangement or a bill-of-material. In building the Structure File, the top level-task (parent) will have secondary level tasks or "component-parts" attached to it. The structure created till he a single, top level task (assembly) with a horizontal string of component parts (referred to as the second level). To add parts vertically to the structure, the second level is considered the parent task and attached to it are its component parts (now becoming the third level of the original task or assembly). This procedure is repeated until the structure is complete. The following illustration will clarify the complete concept. Take the following structure:



This structure can be broken down into separate single-level structures as follows:



This is the method used to enter the structure into SPARDIS. The Structure File defines what "goes into" the next level as well as what raw material is required to manufacture the associated parts.

The Structure File is the networking capability within the SPARDIS System. As will be seen, the network can be time phased to produce data for material requirements planning (MRZ) and other useful management tools. One area of confusion often arises when discussing the SPARDIS piece numbering system and the Structure File. That is, the "level" number in the piece number as opposed to the level in the hierarchy. The "level" indicator has no relation to a components position in the structure file. It is merely an indication of the complexity of the component.

The Routing File defines where operations are to take place to manufacture each level of the structure. We define the operations by assigning work stations which are the places operations will be performed to produce the defined levels of the structure. In order to produce these parts and assemblies, time must be allocated to each operation so that a previous operation is completed prior to beginning the next and so on. In other words, component items must be routed through each designated operation in such a manner as to be completed in time to become part of the next assembly level. In order to accurately accomplish this the phasing, SPARDIS uses Lead Days, or a number of planned work days to complete a given task at a particular operation. These operations are performed at designated work stations and each work station is assigned the number of lead days necessary to accomplish the task. Consequently, if we add up the number of Lead Days for each operation, we will see the total number of lead days necessary to complete the individual task.

As items in SPARDIS are routed, each work station must be made aware of what specifically is required at that operation. To accomplish this, there is a group of numeric instruction codes set up with their verbal meaning contained in the Description File. As an item is routed, the work stations are assigned an instruction number. Based on what is required at that work station, a number is picked from the Description File that applies to that requirement. This "Instruction Code" is placed in the Routing File with the applicable work station and lead days, to provide detail instructions for the planned production of a given item.

The Schedule File defines when the major tasks or assemblies must be complete in order to produce the ship in an orderly fashion. A single calendar date for each major network or structured task is placed in the Schedule File. These dates, one for each major task, taken collectively form the sequence in which the ship is to be built. This date, referred to as the base date or Work Authorized and Released date, is used to determine other key dates for each major task. These key dates are also carried in the Schedule File for monitoring progress against each major task individually. Each major task scheduled in the Schedule File then contains its own set of key dates. These dates are for the following functions:

PRODUCTION

Material Requisition

Material Receipt

Lofting Ccomplete

Work Authorized & Released

Sub-Assembly (Shop) Complete

Erection (Installation) Complete

Fitting

Welding

Inspection

Also tracked within SPARDIS are key dates for both Engineering and Specification Material ordering. These are:

ENGINEERING

Drawing Start thru Approval

Actual Submittal Dates

Actual Performance Dates

Actual Approval Dates

Schedule Dates - Navy (Vendor Information thru issue)

Actual Dates - Navy (Vendor Informtion thru % Complete)

MATERIAL ORDERING

Inquiry Information

Vendor Plans

Purchasing Information

Schedule Delivery

Promised Delivery

Actual Delivery

SUMMARY

These four files, (Description, Schedule, Structure, and Routing) form the Data Base of defined tasks that must be accomplished in order to build ships to specification, ~~schedule and cost limits.~~ These "Master Files" are the planning base from which work is released and monitored throughout the shipyard. All the subsequent information in SPARDIS is created from the Description, Structure, Routing and Schedule Files.

### III WA/R FILE

To provide the information that is necessary to actually produce the components, the Work Authorized and Released (WA/R) File is created. Periodically, a parameter date (some date into the future) is selected. Using this date all major tasks or assemblies that fall within this parameter are selected from the Schedule File. These major task numbers are then used as keys to the Structure File. In turn each component of the associated structure is collected. These new keys in turn are used to select the associated routing and lead days from the Routing File. Since we started with a date from the Schedule File when the task or assembly must be complete, and we found what the components of the assembly are, and the operations and the number of days to perform each operation, we can compute schedule *start* and complete dates for each operation of each component of the structure. This process is called a parts explosion or more commonly a "Chase". This procedure produces the WA/R File.

The WA/R File is the base from which an analysis of Material Requirements is made. It is the file from which shop order documentation is produced to fabricate or assemble components. Actual progress of the various components is reported in this file. Therefore, at any time during the production phase of a part or assembly, inquiry can be made to determine the actual status and location of a given item.

### SUPPLEMENTARY FILES

In addition to the five files which have been described (Description, Structure, Routing, Schedule, and Work Authorized/Released) there are an additional set of Supplementary files which are created and maintained from these for ease of use of the teleprocessing system. These are:

Inventory Status and Multiple Location

Detail Requirements by Date

WA/R Cross Index

Parts Cross Index (Structure)

Source Item Cross Index (WA/R)

MWR Cross Index (Shop Order)

### Inventory Status/Multiple Location File

An Inventory Status Record is created for all common and nested parts. This record contains the primary location of the item and the quantity on hand at that location. It also lists the total (to date) quantities required, ordered, received, issued, staged (obligated), and a cumulative on hand total (*total on hand quantity*). In addition, there **are** other quantity fields that are used in specific processing, such as the Economic Lot Order size, a preliminary estimate of the total quantity required for a contract; and an Adjustment quantity to maintain a record of quantities known to be *lost* or erroneously used.

The Multiple Location Record is used to contain the secondary locations for items stored in more than one location. This record has the capability of holding five (5) locations (in addition to the primary location in the Inventory Status Record) and carries an on hand quantity for each location. This provides for a total of six location fields within the SPARDIS inventory system.



#### Detail Requirements by Date File

After the WA/R data is generated, those requirements flagged as "standard" or "common" (nested), in other words "Inventory items", are extracted. A Detail Requirement Record is established which reflects the date and quantity of the item required. The use of additional processing steps relating to the Detail Requirements File, determines those items that have not been manufactured to support a specified date. This is accomplished by allocating the ordered and released quantity in the Inventory Status to the requirements that exist in the Detail Requirements File in date sequence. When the ordered quantity allocated to requirements is insufficient, additional parts are released to the WA/R File in economic lot order size, as found recorded in the Inventory Status Record.

This process results in establishing the quantities of Inventory Items to be made with a positive date for completion. The same process that creates the WA/R file at the time of Chase is utilized to extract the manufacturing instruction necessary to make the Standard and Common Parts.

#### WA/R Cross Index File

The WA/R Cross Index File is created by extracting data from the Work Authorized/Released File and sorting it in next assembly sequence. The associated displays indicate the status of work complete and locations of the next assembly structure for a given assembly's number as it is currently shown in the WA/R File.

#### Parts Cross Index File

The Parts Cross Index File and its associated on-line, real time display, indicates all places that requirements exist for a given material code, part number, or assembly piece number. Data is removed from the Structure File and is sorted in source item reference number sequence. Any updates to the Structure File, are automatically reflected in the Parts Cross Index File.

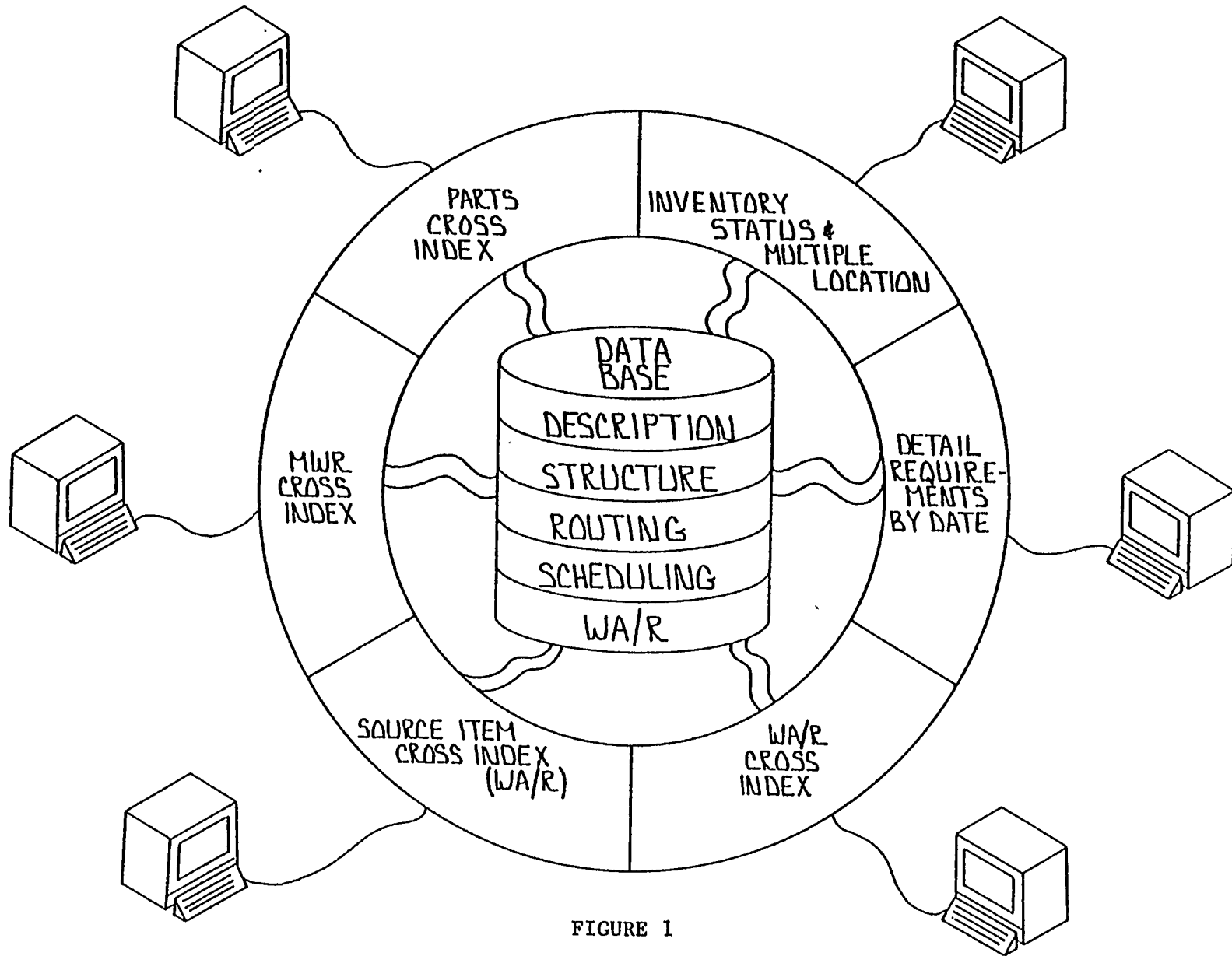
#### Source Item Cross Index File

The Source Item Cross Index File is compiled from data extracted from the WA/R file and is sorted in required date sequence. The associated display shows "where it is used" information pertaining to both raw material source items (for parts) and line item sources (for assemblies). Information displayed is real time and reflects only those records currently contained in the WA/R file.

#### MWR Cross Index File

The Material Withdrawal Request Cross Index File is used for requesting the issue of purchased material from the warehouse. Its major key is its MWR number which is the same as the Shop Order number used in our Shop Order number to list all purchase items necessary to produce a given task. These items are then ordered through the MWR System using the Shop Order number as the key.

Figure 1 is an illustration of the use of these supplementary files for ease of access to the data base. These files are developed to permit efficient use of the teleprocessing system for the user.



### SPARDIS Application

Using the basic concepts discussed, let us examine how we can apply these concepts to control the massive task of building a ship. To do this we must provide management with the visibility to the initial planning effort and later to the actual production progress.

We *must* provide:

- 1) Definitions of the boundaries of tasks and events precisely.
- 2) A list of major tasks that combine many "erection units" into a single event or task.
- 3) As early as possible, material requirement information to ensure accurate material requirements planning (MRP) data.
- 4) A data base from which we can extract the data necessary for actual progress vs. the plan.

Utilizing the Description File we establish a list of key events or tasks which define the major measuring posts that must be passed in order to complete the ship. The SPARDIS keys or numbers for these tasks begin with "X1-". The numbers and their definitions are developed by Production Planning in conjunction with the production supervision. Examples of some of the types of events used are:

X1-1 Land main turbine.

X1-2 Complete installation of boat davits and their associated winches and equipment.

X1-7 Complete installation of pump room package prior to erection of 30' flat.

These events are then scheduled in relation to the major milestones such as keel, launch and delivery. The schedules for the major tasks are input into the Schedule File. The Schedule File then contains a set of event related completion dates which taken collectively, form the sequence in which the ship is to be built.

The defined tasks or events now form one level of our hierarchical arrangement. Continuing, we develop the supporting tasks in order to further define the component *structure* of the major task. Production Planning begins by defining these assemblies or packages of work in the Description File. These lower level components are generally prefixed by an "X1-" or "X2". For example let us call one of these lower level components A2-65 which we will define as the structural unit "Innerbottom unit 6" port to 29' off CL stbd., C-D-E3 stks, girders, transverse floors, frame 71 to 6" aft of frame 85 starboard". This unit which is part of the pump room is then structured as a component of the event which it will support. All other components of the event are also defined and structured. These components form another level in our hierarchy.

Each of these components becomes the parent assembly and their component structures are added until the raw material components are reached. In this manner we have created a multi-level hierarchical arrangement of components beginning with the highest level monitoring post.

Let us examine one of these major tasks to better understand the data base we are creating. We will use as our example:

X1-7 Complete installation of pump room package prior to erection of the 30' flat.

Figure 2 is an illustration of where the pump room is located in the ship. It consists of the supporting structure as well as the major pump room components. The structure of this package can be simplified by looking only at the major components. This structure will take the following form:  
STRUCTURE OF X1-7:

<u>LINE</u>	<u>COMPONENT</u>	<u>DESCRIPTION</u>
01	A2-35	BOTTOM SHELL PLATING
02	A2-64	INNERBOTTOM - PORT
03	A1-65	INNERBOTTOM - STBD W/PIPING
04	A2-129	TRANSVERSE BHD FR 71 PORT
05	A2-130	TRANSVERSE BED FR 71 STBD
06	P2-30	PIPING THROUGH TANK TOP
07	P2-22	PUMP ROOM PIPING TANK TOP TO 30' FLAT
08	A2-157	LONG'L BHD PORT
09	A2-152	SIDE SHELL
10	A2-159	TRANSVERSE BHD FR 80 STBD
11	A2-160	LONG'L BHD STBD
12	A2-158	TRANSVERSE BHD FR 80 PORT
13	W2-21	BUTTERWORTH HEATER & DRATIN COOLER

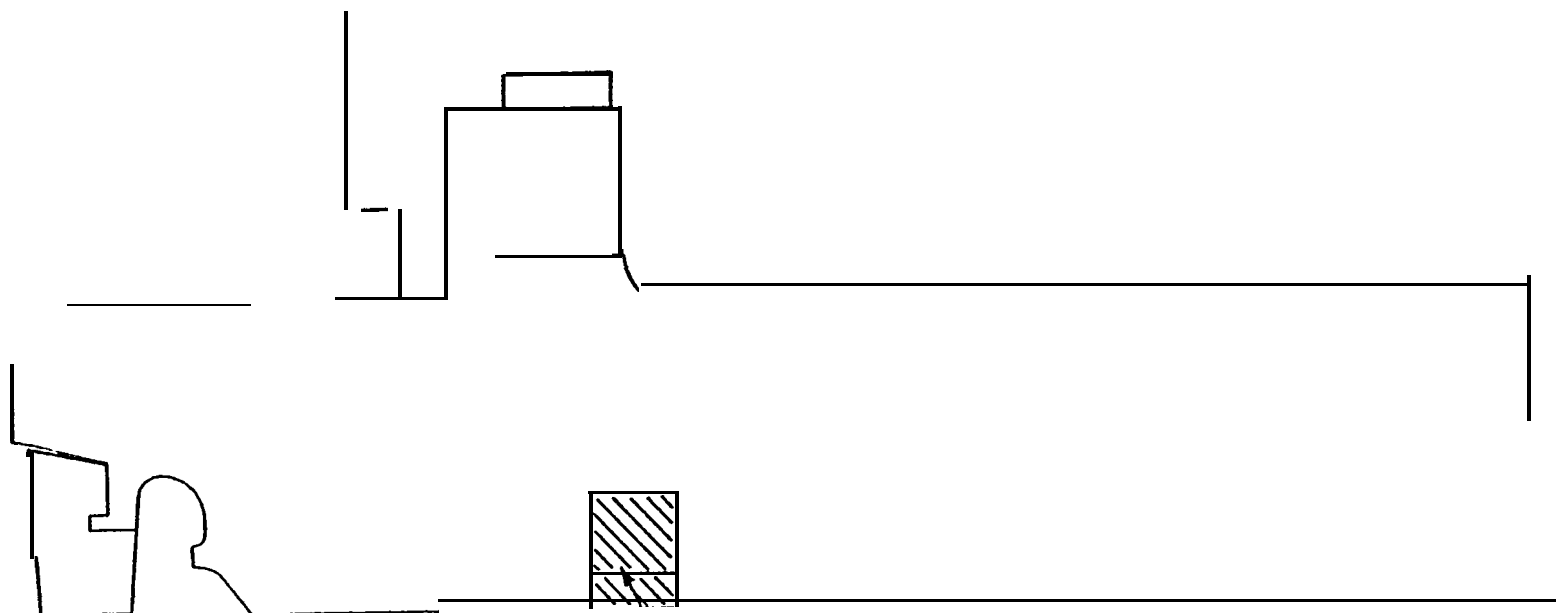
Each of these components in turn have their own structural components. For example A1-65 has as its components:  
STRUCTURE OF A1-65:

<u>LINE</u>	<u>COMPONENT</u>	<u>DESCRIPTION</u>
01	A2-65	INNERBOTTOM - STBD
02	P2-20	INNERBOTTOM PIPING

These in turn have their own component structures. This process is continued in a "top down" planning sequence until the lowest level component is reached. In this manner we have formed a detail network of the events leading up to the completion of the task. You will note that the component number has no relation to its position or level in the structure.

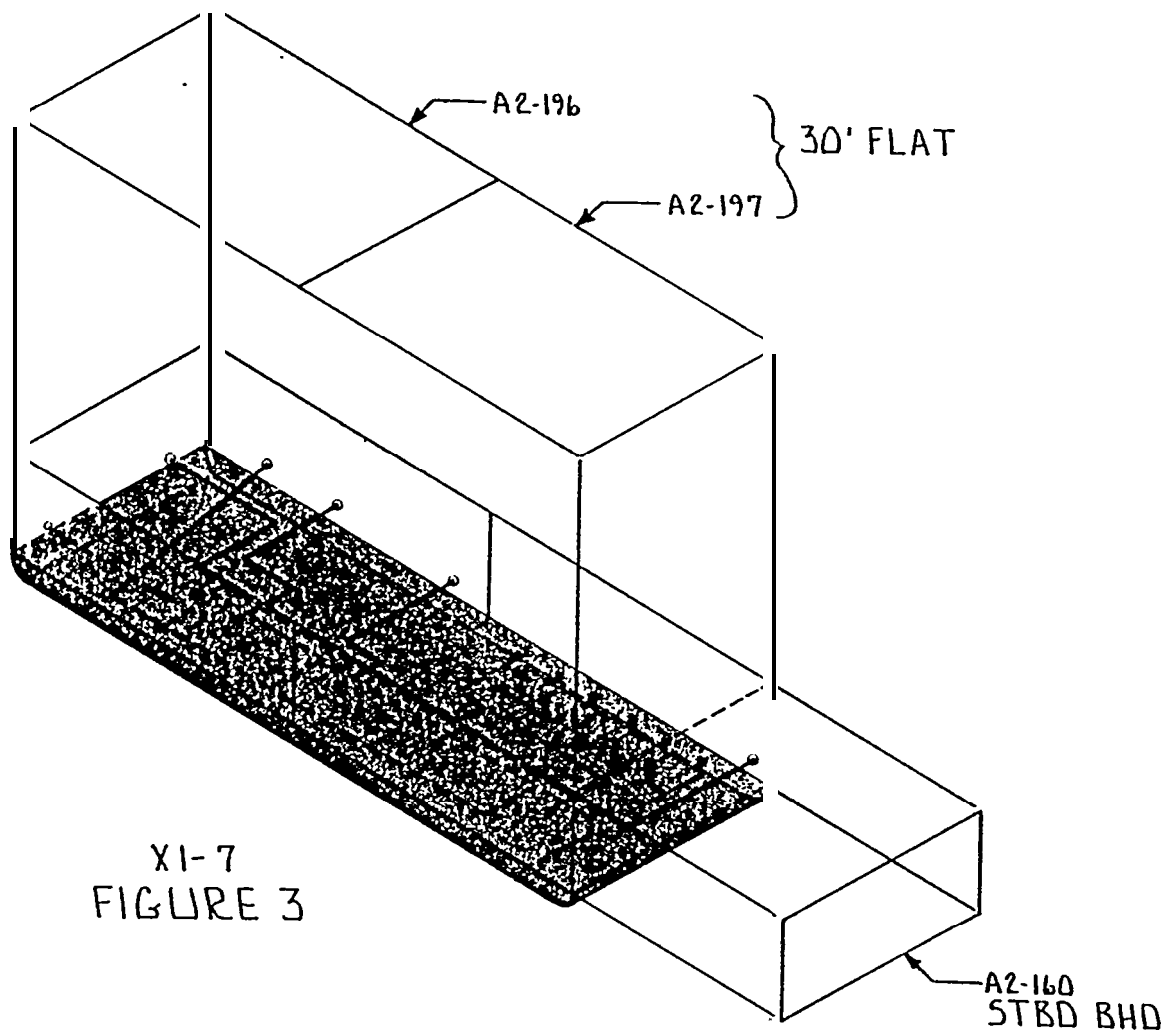
Figures 3 through 7 are given for illustration of the concept.

Each of these components is described, structured, and routed in the SPARDIS System. Routinely the four master files (Description, Schedule,



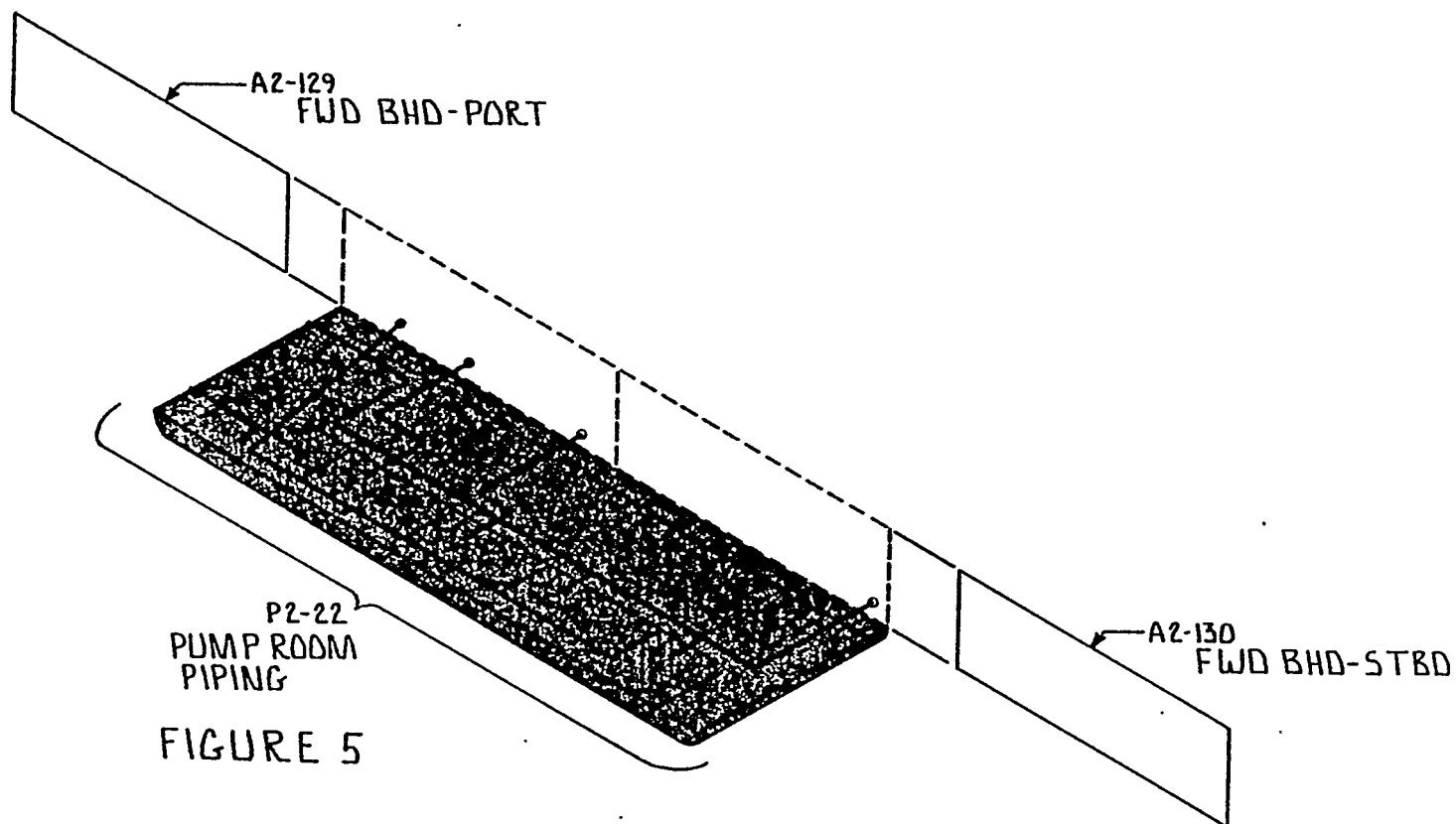
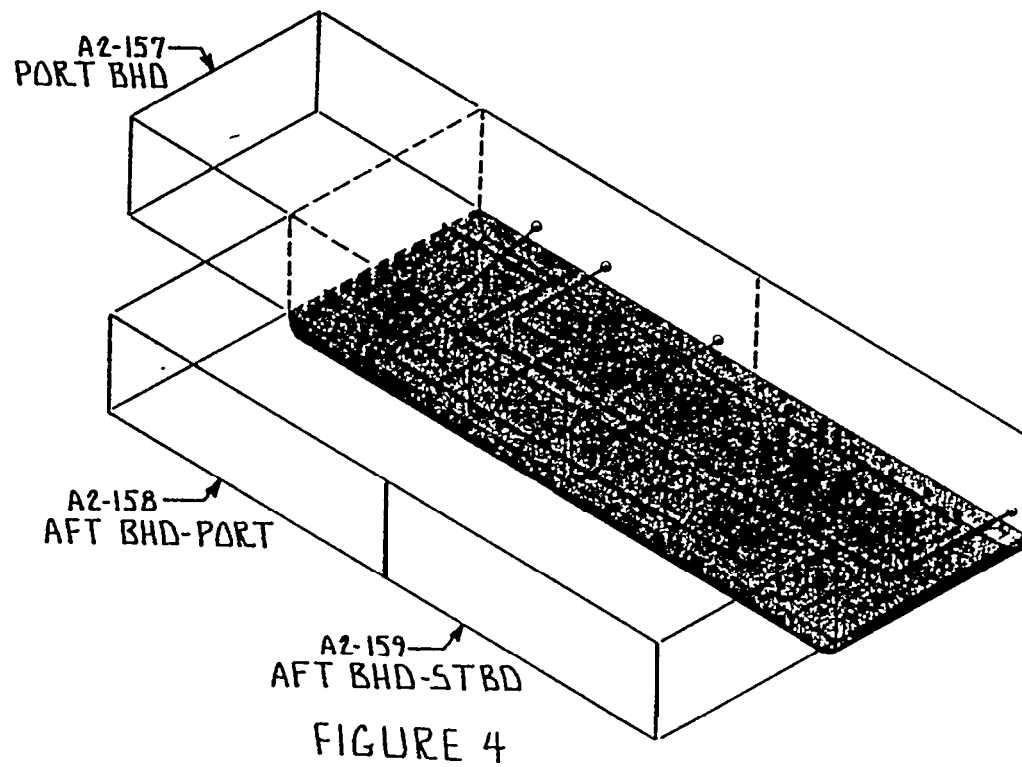
X1-7  
PUMP ROOM PACKAGE

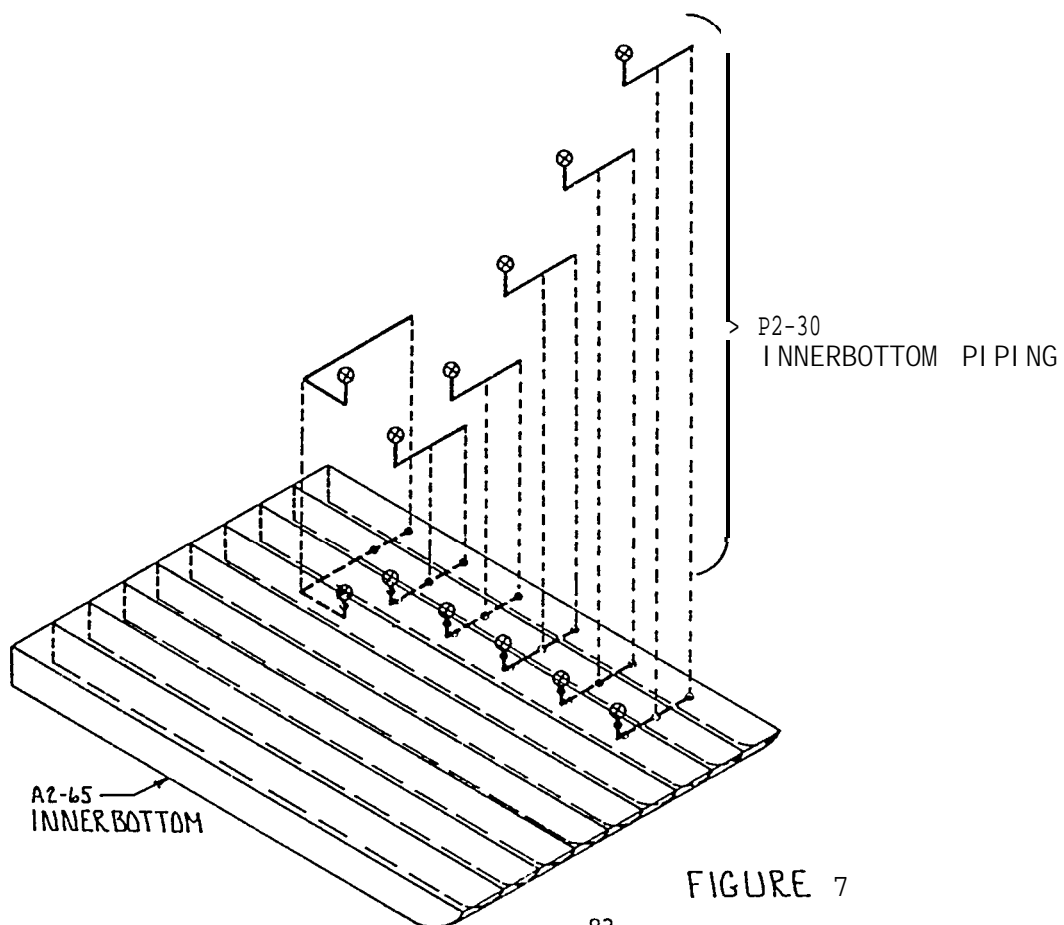
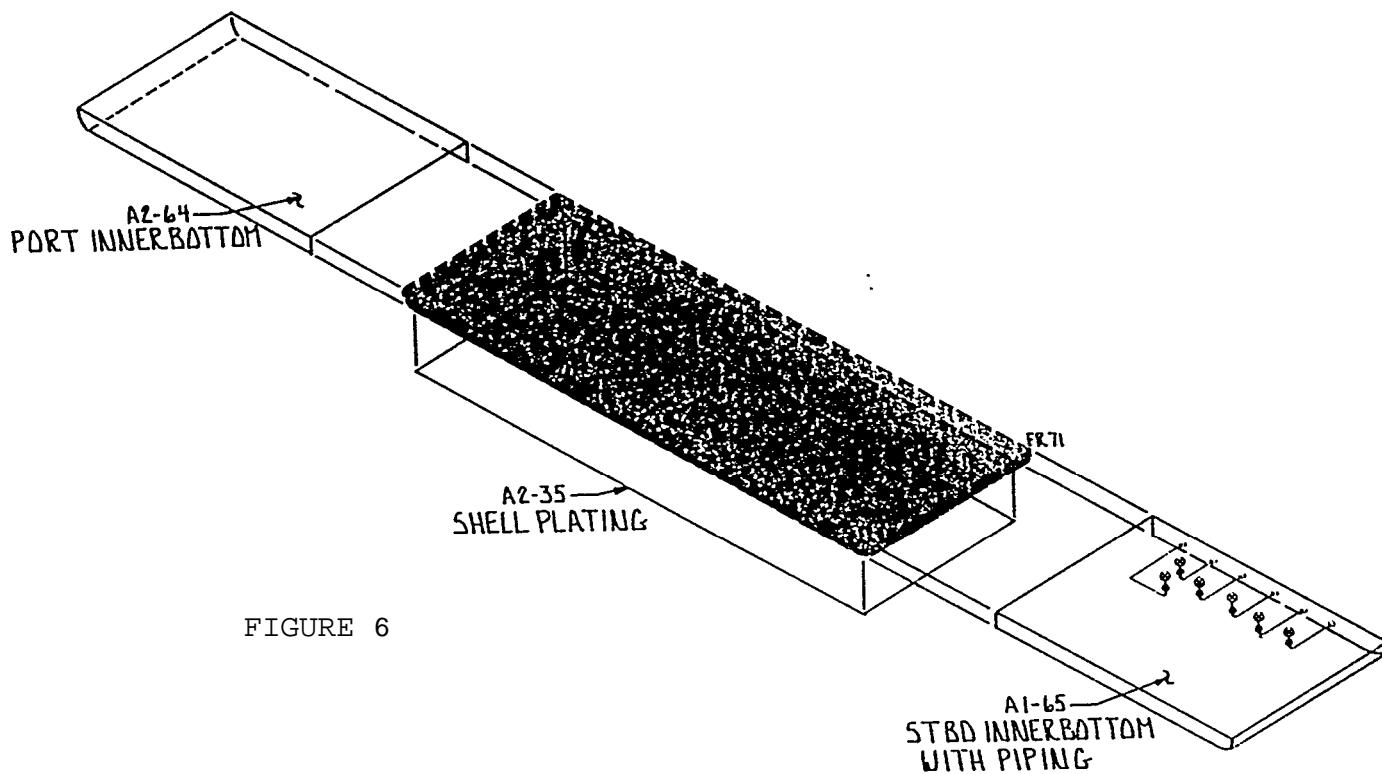
FIGURE 2



X1-7  
FIGURE 3

A2-160  
STBD BHD





Structure, Routing) are combined through a parts explosion or chase process. This allows a scheduled start and completion date to be applied to the network.

This new set of data, called the Work Authorized/Released File, is used to examine material availability. To do this the WA/R data set is compared to the inventory and purchase order files and exception reports are generated. These exception reports are used by the purchasing department for expediting material to ensure material availability. Weekly, a portion of this WA/R data set is used to prepare detail production information to construct the ship. This information is in a special form called shop orders. A shop order is prepared for each level of the structure and is used both as an authorization for work and as a progressing tool in the shipyard. Data is maintained in the WA/R File as-to the actual status of components, with their location, in real time. This data is routinely entered into the system via remote terminals which are strategically placed throughout the shipyard. Status and progress information is available to anyone in the shipyard by a simple inquiry on one of these terminals.



## SHOP ORDER SYSTEM

The Shop Order provides 2 means of authorizing production to produce a component in the shipyard. The shop order is a computer generated document which provides the necessary information to accomplish a single task. It is a tool which allows shipyard management to allocate the resources necessary to accomplish specific tasks. The shop order documents are tied directly to the withdrawal of purchased components as will. be shown later.

The shop order system has three primary components (See Figure 8) :

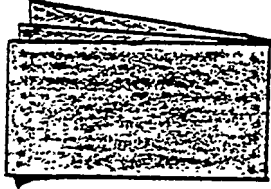
- 1) shop Order - a printed document providing the necessary information to accomplish a single task. The shop order card is a three-part snap-out form, 8 1/2 x 5 1/2 inches in size. The first sheet of the set is a yellow light-weight original, the second sheet is a green light-weight carbon copy and the third sheet is a heavy card stock carbon copy.
- 2) Work Station Schedule Log - a printed document which provides a list of shop orders for a specific work station, in date order. The work station schedule log is printed on standard computer paper 8 1/2 x 14 inches.
- 3) Teleprocessing System - a system of communication lines and terminals used to communicate with the Spardis system. These terminals are used for both inquiry and updating of the work in process. This permits the user to make decisions in his dynamic environment based on the latest information available. His-decision making is aided in the knowledge of the latest status information as well as knowing where to go to get a part or assembly.

Weekly, as part of the chase or parts explosion process, shop orders are printed for work which has been authorized by Production Planning. A separate shop order is printed for each operation for each level of the network. That is, each work station that is to perform work on a specific component receives its own shop order. The shop orders are bundled, by work station, by scheduled start date, with the appropriate Work Station Schedule Log. As shop orders are printed, a number is attached to the shop order and its corresponding WA/R File record. This number is used in ordering purchased material from the warehouses as well as for filing purposes. The number is non-significant.

The work station schedule log is designed for use by the production foreman. It lists all work to be started on a specific day and indicates when each shop order must be completed to support the next level of events in the network. Space is provided for any annotations desired by the foreman.

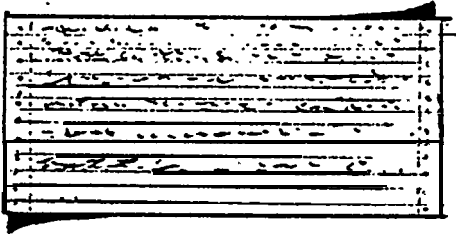
The shop order provides detailed instructions to clearly define the planned task. However, space is provided on the shop order form for the foreman to indicate any additional operations that must be performed.

The Shop Order System Consists of:



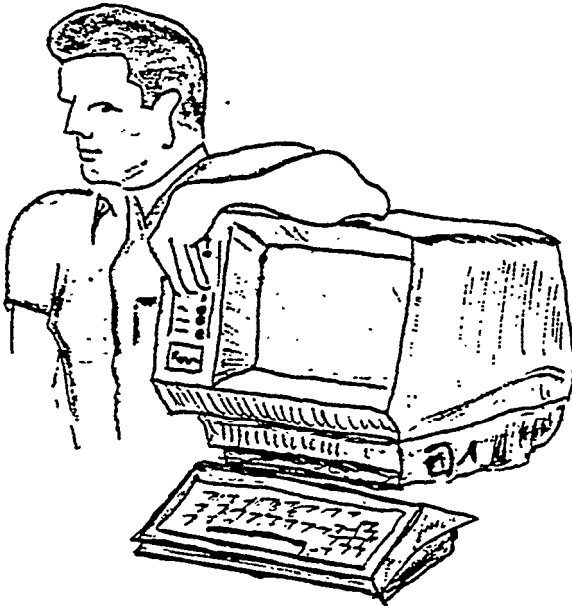
**SHOP ORDER**

Three part snap-out form  
with carbons



**WORK STATION SCHEDULE LOG**

Foreman 's listing of jobs per  
Work Station per day.



TELEPROCESSING SYSTEM (CRT)  
Informational inquiry and  
Work Station Update.

AND YOU -----THE USER

FIGURE 8

When the operations indicated have been performed the three copies of the shop order are used as follows:

- 1) Yellow - turned in to the Production Control Department to indicate the task is complete. In turn the corresponding WA/R File record is updated showing when the work was accomplished.
- 2) Green - shipping document, a traveler attached to the component to get it to its next work station; or discarded if the task level has been reached.
- 3) Heavy Card Stock - returned to the foreman so that he may update his records. If additional operations were required the form is returned to Production Planning so that the corresponding records can be corrected for any subsequent releases. It becomes a feed back document.

The shop orders are used throughout the shipyard and are the instrument by which material is progressed through its fabrication, assembly and installation cycles. Figure 9 is a diagram of the use of the shop orders. Figures 10 & 11 are examples of shop orders and work station schedule logs, respectively.

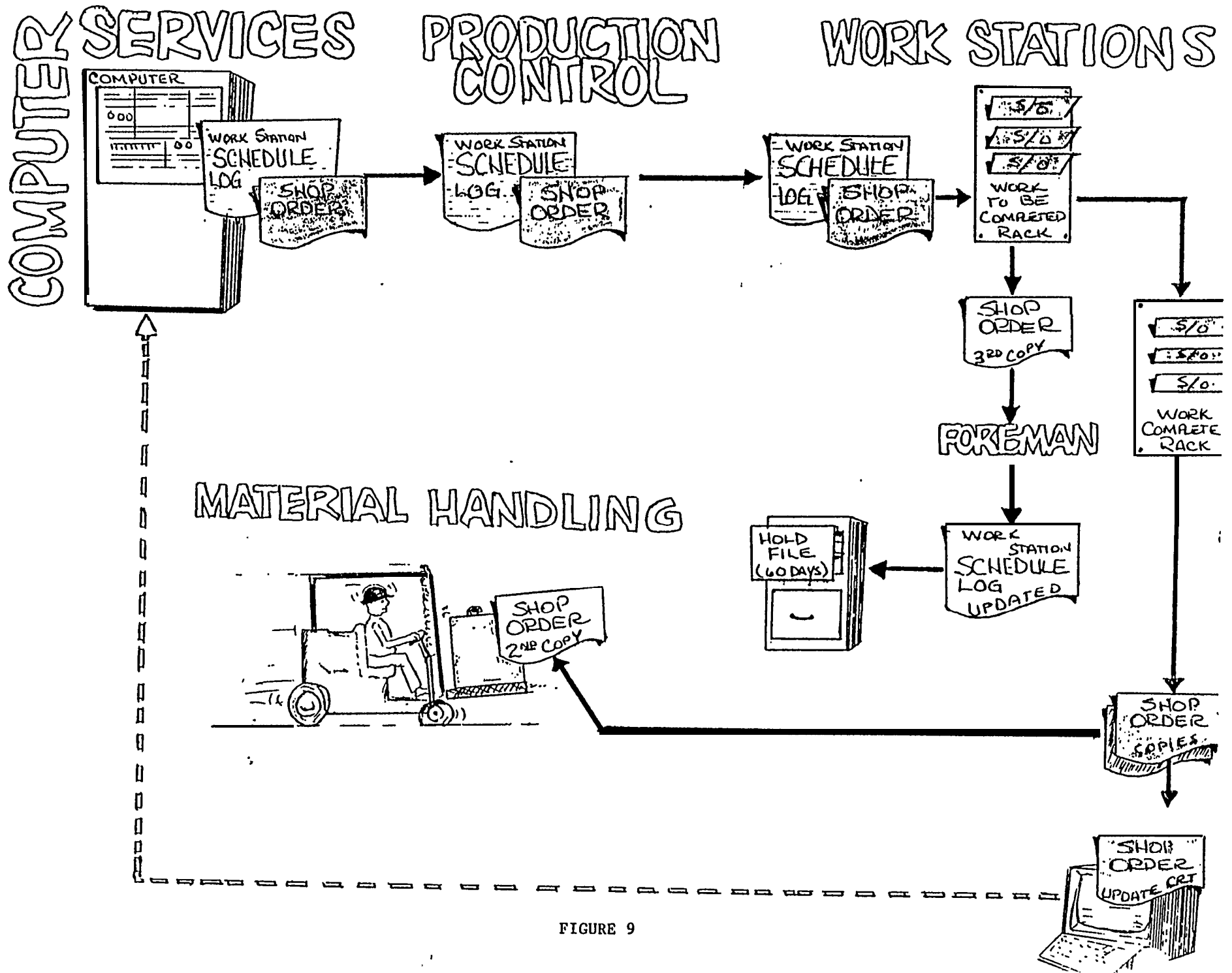


FIGURE 9

<b>PURPOSE:</b> To provide a printed hard-copy document that authorizes and releases to Production the information necessary to accomplish a specific task at a specific Work Station.	<b>SCOPE :</b> Details instructions for the steps required in tile fabrication of Parts & Assemblies & the performance of tasks. The SHOP ORDER authorizes Production to accomplish work.	<b>FREQUENCY :</b> Daily, from 360-3 Transmittal Form & following a Final Change.	<b>REPORT Number:</b> 56127  <b>Title:</b> SHOP ORDER
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HUP ORD 302611-2 \*\*W/S 025 14 ATFN ROLLS (AT SOUTH END OF RAISED SLAB) 56127  
WG 398-100-009- - - HULL 398 PRI/OP 001 SIB/DP 033. START DATE 04/27/6  
EF R A9-2073 REL 001 LNE 000 CKCD 2089 QTY EMPLOC (SEE INST) WEIGHT ( 4.7) TONS  
/A R A3-239 DESC. PL 26-775#X110-1/2-X36"-00"  
/A R A2-106 REMARKS:  
NSTL/D TO W-2PC (W10-14). 6 HULL SETS 3 FR-01-1/4, 02-1/2, 02-3/4, 03-1/4, 04-1/2 CKS (R15-1-5)  
1 CD REF HQ REL QTY USE MS DESCRIPTION/REMARKS (TIME CHARGE NO 6398-100-009-1001)  
2 026043 1 EA AN PL 26-775#X12X450

(ADDITIONAL OPERATIONS)

SHOP ORD 302609-6 \*\*W/S 035 JIG AREA - PLATEN FABRICATION SUB-ASSEMBLY 56127  
DWG 398-100-009-4A - 02-B HULL 398 PRI/OP 000 SUB/DP 035. START DATE 05/07/6  
REF R A2-106 REL 001 LNE 000 CKCD 1020 QTY TEMPLOC (ASSEMBLY)  
N/A R A2-106 DESC. SIDE SHELL, G-H-J-K-L-M STRAKES, WITH VERTICAL WEIGHT ( 1.0) TONS  
P/A R A2-106 REMARKS: 10" AFT 01 TO 10" AFT 04. PORT.  
INSTASSEMBLY AS PER DETAILS ON DRAWING.

LNE	CD	REF	NO.	UI	QTY	DESCRIPTION	TIME CHARGE NO
001	A3-239	EA			1	SIDE SHELL PLATING ASSY- FRAMES 01 TO 04. PORT.	398-100-009-06B-02-1
002	A4-203	EA			1	VERTICAL WEB FRAME, ON SIDE SHELL, FRAME 02. PORT. STIFFS AFT.	398-100-009-10A-03-1
003	A4-204	EA			1	VERTICAL WEB FRAME, ON SIDE SHELL, FRAME 03. PORT. STIFFS AFT.	398-100-009-11A-03-0
004	A4-205	EA			1	VERTICAL WEB FRAME, ON SIDE SHELL, FRAME 04. PORT. STIFFS AFT.	398-100-009-11A-03-1
005	2-A9-2129	EA			1	AN 7"X4"X7/16"X35"-03"	398-100-009
006	2-A9-2131	EA			1	(SIS #08) AN 7"X4"X7/16"X35"-03"	398-100-009
007	2-A9-2133	EA			1	(SIS #08) AN 8"X4"X1/2"X35"-03"	398-100-009
008	2-A9-2135	EA			1	(SIS #08) AN 8"X4"X1/2"X35"-03"	398-100-009
009	2-A9-2137	EA			1	(SIS #08) AN 9"X4"X1/2"X35"-03"	398-100-009
010	6-A9-2139	EA			1	(SIS #08) AN 10"X4"X1/2"X35"-03"	398-100-009

CONTINUED

Sample of SPARDIS computer-generated SHOP ORDER card for a unique, individual Part number. Actual size of card: 8-1/2" x 5-1/2".

Sample of SPARDIS computer-generated SHOP ORDER card for an Assembly Work Station. Actual size of card: 8-1/2" x 5-1/2".

① **SHOP ORD** - Computer-assigned SHOP ORDER identification number.  
**W/S** - 3-digit Work Station & description of Work Station.  
**START DATE** - The scheduled work date that the fabrication of Reference Number should commence.

② **DWG** - The specific blueprint (Drawing) & location that Reference Number can be viewed.  
**HULL** - The NASSCO-assigned Hull number.  
**PRI/OP** - Indicates the previous operation or Work Station that the Reference Number was shipped from.  
**SUB/OP** - This field indicates all subsequent Work Station(a) that the Reference Number must progress through before completion of this Level:

③ **REF** - Identifies the Hull Code & the SPARDIS Reference Number (Piece Number) identification.  
**REL** - Indicates the Release Number of the Reference Number.  
**LNE** - Specifies the Line Item within the Reference Number's structural matrix for the specific Release indicated.  
**CKCD** - Computer-assigned Check Code. This Code is intended to negate improper updates (such as a number transposition by personnel entering on-line updating).  
**Q T Y** - Indicates the quantity of the Reference Number required for this particular Release Number.

(Continued on next page)

<b>PURPOSE:</b> To provide 1 printed hard-copy document that authorizes 1 and releases to Production the information necessary to accomplish 1 specific task at a specific Work Station.	<b>SCOPE :</b> Details instructions for the steps required in the fabrication of Parts & Assemblies & the performance of tasks. The SHOP ORDER 1 authorize production to accomplish work.	<b>FREQUENCY:</b> Daily, from 360-3 Transmittal Form & following . Final Chase.	<b>REPORT Number:</b> S6127  <b>Title:</b> SHOP ORDER
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<p>SHOP ORD 382611-2 00W/S 025 PLATEN ROLL'S (AT SOUTH END OF RAISED SLABS S6127) V6 398-100-009- HULL 708 PRI/OP 001 SUB/OP 035: START DATE 04/27/76</p> <p>EF R A9-2073 REL 001 LINE 000 CKCD 2049 QTY TEMPLC (SEE INST) WEIGHT 1 4.71TONS /A R A3-239 DESC. PL 26.775X118-1/2-X36-03- REMARKS2- /A R A2-106</p> <p>INST:LD TO W-2PC (V18-14). 6 ROLL SETS 3 FR-81-1/4.82.82-1/2.82-3/4 .83-1/4.84-12 CKS (R18-1-3)</p> <p>1 CD REF NO REL QTY US MS DESCRIPTION/REMARKS (TIME CHARGE NO 6398-100-009-100) 2 826043 1 EA AN PL 26.775X122X459</p> <p>(ADDITIONAL OPERATIONS)</p>	<p>1 SHOP ORD 382609-6 00W/S 025 JIG AREA.- PLATEN FABRICATION SUB-ASSEMBLY S6127 2 DNG 398-100-009-6A - 02-B HULL 398PRI/OP 000 SUB/OP 035: START DATE 05/07/76</p> <p>3 REF R A2-106 REL 001 LINE 000 CKCD 1020 QTY TEMPLC (ASSEMBLY WEIGHT 1 4.71TONS) 4 N/A R A2-106 DESC. SIDE SHELL-G-H-J-K-L-M STRAKES. WITH VERTICAL REMARKS: 1 PART A1 TO 10-APT 84. PORT. INST:ASSEMBLE AS PER DETAIL ON DRAWING.</p> <table border="1"> <thead> <tr> <th>LINE</th> <th>CD</th> <th>REF NO.</th> <th>US</th> <th>QTY</th> <th>DESCRIPTION</th> <th>(TIME CHARGE NO 6398-100-009-100)</th> </tr> </thead> <tbody> <tr> <td>001</td> <td>A3-239</td> <td>EA</td> <td>1</td> <td>SIDE SHELL PLATING ASSY. FRAMES B1 TO 84. PORT.</td> <td>398-100-009-068-02-4</td> </tr> <tr> <td>002</td> <td>A4-203</td> <td>EA</td> <td>1</td> <td>VERTICAL WEB FRAME. ON SIDE SHELL. FRAME 82. PORT. STIFFS APT.</td> <td>308-100-009-10A-03-4</td> </tr> <tr> <td>003</td> <td>A4-204</td> <td>EA</td> <td>1</td> <td>VERTICAL WEB FRAME. ON SIDE SHELL. FRAME 83. PORT. STIFFS APT.</td> <td>398-100-009-11A-03-4</td> </tr> <tr> <td>004</td> <td>A4-205</td> <td>EA</td> <td>1</td> <td>VERTICAL WEB FRAME. ON SIDE SHELL. FRAME 84. PORT. STIFFS APT.</td> <td>308-100-009-11A-03-4</td> </tr> <tr> <td>005</td> <td>2-A9-2129</td> <td>EA</td> <td>1</td> <td>AN 7"x4"x17/16-X35-03</td> <td>398-100-009</td> </tr> <tr> <td>006</td> <td>2-A9-2133</td> <td>EA</td> <td>1</td> <td>AN 7"x4"x17/16-X35-03</td> <td>198-100-009</td> </tr> <tr> <td>007</td> <td>2-A9-2133</td> <td>EA</td> <td>1</td> <td>AN 8"x4"x1/2-X35-03</td> <td>398-100-009</td> </tr> <tr> <td>008</td> <td>2-A9-2138</td> <td>EA</td> <td>1</td> <td>AN 8"x4"x1/2-X35-03</td> <td>398-100-009</td> </tr> <tr> <td>009</td> <td>2-A9-2137</td> <td>EA</td> <td>1</td> <td>AN 8"x4"x1/2-X35-03</td> <td>398-100-009</td> </tr> <tr> <td>010</td> <td>6-A9-2139</td> <td>EA</td> <td>1</td> <td>AN 10"x4"x1.04/73X35-03</td> <td>398-100-009</td> </tr> <tr> <td>011</td> <td>6-A9-2139</td> <td>EA</td> <td>1</td> <td>AN 10"x4"x1.04/73X35-03</td> <td>398-100-009</td> </tr> </tbody> </table> <p>6 CONTINUED</p>	LINE	CD	REF NO.	US	QTY	DESCRIPTION	(TIME CHARGE NO 6398-100-009-100)	001	A3-239	EA	1	SIDE SHELL PLATING ASSY. FRAMES B1 TO 84. PORT.	398-100-009-068-02-4	002	A4-203	EA	1	VERTICAL WEB FRAME. ON SIDE SHELL. FRAME 82. PORT. STIFFS APT.	308-100-009-10A-03-4	003	A4-204	EA	1	VERTICAL WEB FRAME. ON SIDE SHELL. FRAME 83. PORT. STIFFS APT.	398-100-009-11A-03-4	004	A4-205	EA	1	VERTICAL WEB FRAME. ON SIDE SHELL. FRAME 84. PORT. STIFFS APT.	308-100-009-11A-03-4	005	2-A9-2129	EA	1	AN 7"x4"x17/16-X35-03	398-100-009	006	2-A9-2133	EA	1	AN 7"x4"x17/16-X35-03	198-100-009	007	2-A9-2133	EA	1	AN 8"x4"x1/2-X35-03	398-100-009	008	2-A9-2138	EA	1	AN 8"x4"x1/2-X35-03	398-100-009	009	2-A9-2137	EA	1	AN 8"x4"x1/2-X35-03	398-100-009	010	6-A9-2139	EA	1	AN 10"x4"x1.04/73X35-03	398-100-009	011	6-A9-2139	EA	1	AN 10"x4"x1.04/73X35-03	398-100-009
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001	A3-239	EA	1	SIDE SHELL PLATING ASSY. FRAMES B1 TO 84. PORT.	398-100-009-068-02-4																																																																					
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005	2-A9-2129	EA	1	AN 7"x4"x17/16-X35-03	398-100-009																																																																					
006	2-A9-2133	EA	1	AN 7"x4"x17/16-X35-03	198-100-009																																																																					
007	2-A9-2133	EA	1	AN 8"x4"x1/2-X35-03	398-100-009																																																																					
008	2-A9-2138	EA	1	AN 8"x4"x1/2-X35-03	398-100-009																																																																					
009	2-A9-2137	EA	1	AN 8"x4"x1/2-X35-03	398-100-009																																																																					
010	6-A9-2139	EA	1	AN 10"x4"x1.04/73X35-03	398-100-009																																																																					
011	6-A9-2139	EA	1	AN 10"x4"x1.04/73X35-03	398-100-009																																																																					

Sample of SPARDIS computer-generated SHOP ORDER card for a unique, individual Part number. Actual size of card: 8-1/2" x 5-1/2".

Sample of SPARDIS computer-generated SHOP ORDER card for an Assembly Work Station. Actual size of card: 8-1/2" x 5-1/2".

- 3 (Continued from last page)
- TEMPLC** = Template Location: Specifies the storage location of MOLD LOFT-prepared Layout & fabrication templates. On the above sample, the word ASSEMBLY indicates that all of the component Parts have already been layed-out & fabricated, thus the function of this Assembly Work Station 035 is to weld all of the components & parts (tabulated in Detail 5 above) together to produce the structurally complete modular component Reference Number R A2-106.
- WEIGHT - TONS** = Indicates the accumulated weight (short tons) of all of the individual Parts for Level 1 Assemblies and for Levels 3 through 7. This weight factor does not include the weight of weld or other joining medium. On a Part Level, only the weight of the Part itself is shown. This field also assists Riggers in assignment of proper Transportation equipment when movement of a Part or Assembly is pending.
- 4 N/A Indicates the Next Assembly to which the Reference Number is deatined. On the above right-hand sample for R A2-106, both the Next & Final Assembly reflects self-finslization because this Unit is a Level 1 Erection Sequence. The left-hand sample for R A9-2073 indicate R A3-239 as its Next Assembly; subsequently R A3-239 moves to R A2- 106 and will become an intcgral part of R A2-106.
- DESC** = This field describes the Reference Number.
- INS** = Details exact fabrication/handling instructions for Reference Number.
- TIME CHARGE No.** = Labor charge reference to be entered on workers' time cards for charging the various Trades' time to the Specified Hull.

(Continued on next page)

<b>Purposes:</b>	<b>SCOPE:</b>	<b>FREQUENCY:</b>	<b>REPORT Number:</b> S6127
To provide a printed hard-copy document that authorizes and releases to Production the information necessary to accomplish a specific task at a specific Work Station.	Details instructions for the steps required in the fabrication of Parts & Assemblies & the performance of tasks. The SHOP ORDER authorizes Production to accomplish the work,	Daily, from 360-3 Transmittal Form & following a Final Chase.	<b>Title:</b> SHOP ORDER

HOP ORD 302611-2 00W/S 025 PLATEN ROLLS (AT SOUTH END OF RAISED SLAB) S6127  
 VG 398-100-009- HULL 398 PRI/OP 001 SUB/OP 035 START DATE 04/27/6  
 EF R A9-2073 REL 001 LNE 000 CKCD 2089 QTY TEMPLOC (SEE INST) WEIGHT (SEE INST)  
 /A R A3-239 DESC. PL 26-775/K115-1/2-X35-03  
 /A R A2-106 REMARKS: 10' AFT 01 TO 10' AFT 04, PORT.  
 NSTSL/D TO V-2PC (W10-14), 6 HULL SETS 2 FR-01-1/4-02-02-1/2-02-3/  
 ,03-1/4-04-12 C/S (R14-1-31)  
 I CD REF NO REL QTY UI AS DESCRIPTION/REMARKS  
 2 826043 1 EA AH PL 26-775/K122X450  
 (ADDITIONAL OPERATIONS)

1 SHOP ORD 302609-8 00W/S 035 JIG AREA - PLATEN FABRICATION SUB-ASSEMBLY S6127  
 2 HULL 398 PRI/OP 000 SUB/OP 035 START DATE 05/07/6  
 3 REF R A2-106 REL 001 LNE 000 CKCD 1020 QTY 1 TEMPLOC (ASSEMBLY)  
 4 N/A R A2-106 DESC. SIDE SHELL, G-H-J-K-L-N STRAKES, WITH VERTICAL WEIGHT (SEE INST)  
 P/A R A2-106 REMARKS: 10' AFT 01 TO 10' AFT 04, PORT.  
 INSTASSEMBLY AS PER DETAILS ON DRAWING.  
 LNE CD REF NO. UI QTY DESCRIPTION (TIME CHARGE NO 6398-100-009-  
 001 A3-239 EA 1 SIDE SHELL PLATING ASSY. DRAWING)  
 FRAMES 01 TO 04, PORT.  
 002 A4-203 EA 1 VERTICAL WEB FRAME, ON SIDE SHELL, 398-100-009-060-02-0  
 FRAME 02, PORT. STIFFS AFT. 398-100-009-10A-03-0  
 003 A4-204 EA 1 VERTICAL WEB FRAME, ON SIDE SHELL, 398-100-009-11A-03-0  
 FRAME 03, PORT. STIFFS AFT. 398-100-009-11A-03-0  
 004 A4-205 EA 1 VERTICAL WEB FRAME, ON SIDE SHELL, 398-100-009-11A-03-0  
 FRAME 04, PORT. STIFFS AFT. 398-100-009-11A-03-0  
 005 2-A9-2129 EA 1 AN 7"x4"x7/16"x35-03 398-100-009  
 006 2-A9-2131 EA (SEE #89) 398-100-009  
 1 AN 7"x4"x7/16"x35-03 398-100-009  
 007 2-A9-2133 EA (SEE #89) 398-100-009  
 1 AN 8"x4"x1/2"x35-03 398-100-009  
 008 2-A9-2135 EA (SEE #89) 98-100-009  
 1 AN 8"x4"x1/2"x35-03 98-100-009  
 009 2-A9-2137 EA (SEE #89) 398-100-009  
 1 AN 9"x4"x1/2"x35-03 398-100-009  
 010 4-A9-2139 EA (SEE #89) 398-100-009  
 1 AD 10"x4"x1/4"x75x35-03 398-100-009  
 6 7 CONTINUED

Sample of SPARDIS computer-generated SHOP ORDER card for a unique, individual Part number. Actual size of card: 8-1/2" x 5-1/2".

Sample of SPARDIS computer-generated SHOP ORDER card for an Assembly Work Station. Actual size of card: 8-1/2" x 5-1/2".

- 5 LNE - Specifies the Line Item within the Reference Number's internal structure (Detail (3) above).  
 CD - Indicates the Source Item Material Code identification number which specifies NASSCO'S method of material acquisition.  
 REF NO - For Level 1 Assemblies, this field lists the Parts, other Assemblies, or components that are structured into Ref. No. (Detail (3) above).  
 For a Part Level, this field specifies the material Source Item Code number required to produce the Part.  
 UI - Unit of Issue: This 2-digit alpha field establishes the Source Item Code measurement/qty factor: Example: EA - a complete entity.  
 LF - linear footage.  
 QTY - The quantity of that particular Line Item Reference Number required for the Level 1 Reference No. (Detail (3) above).  
 DESC - Details the Assembly description or specifies the physical dimension of the Line Item Reference Number.  
 DWG - Indicates the specific blueprint (Drawing) & location on the blueprint which the Line Item may be viewed.  
 6 (SIS #89) - Refers to a separate document "Supplemental Instruction Sheet" that more fully defines special or complex fabrication data.  
 7 CONTINUED - Alerts the user that the next Line Item of structure is continued on the next SHOP ORDER card.

END

<b>PURPOSE:</b> To provide a computer-generated printed document for Production Foremen which tabulates complete daily scheduled tasks for each Work Station under his supervision - for projecting maximum utilization of facilities.	<b>SCOPE:</b> Two-fold: (1) Provides a composite tabulation of the daily scheduled tasks for individual Work Stations, listing Start & Complete dates. (2) By issuing the Log to Foremen several work-days in advance, maximum utilization of available manpower, equipment & machine-loading can be realized.	<b>FREQUENCY:</b> Daily.	<b>REPORT Number:</b> S6134  <b>Title:</b> WORK STATION SCHEDULE LOG
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①	④	⑤	⑥	⑦	⑧	⑨	⑩	③	
DATE PREPARED 05-09-70	WORK STATION SCHEDULE LOG 025	N/A	F/A	PRI OP	COMPLETE DATE				
0134	HULL REF NO	REL	ASSIGN TO	DATE COMPL MADE	QTY COMPLETED BY	UI	QTY REV	SOURCE STOCK	ITEM QTY
05257-7	389 A9-6106	002				EA		021402	1
05259-3	389 A9-6107	002				EA		021402	1
05281-7	389 A9-6095	002				EA		021458	1
05294-0	389 A9-6096	002				EA		021458	1
END									

① <u>DATE PREPARED</u> - The date that the computer produced this print-out. ② <u>025</u> - Indicates the Work Station for which this Log is issued. ③ <u>START DATE</u> - The scheduled Start Date for all items listed on Log. ④ <u>S/O</u> - Designates the SHOP ORDER number for this Release of Ref. No. <u>HULL</u> - Indicates the Hull Number applicable for Release of Ref. No. <u>REF NO.</u> - The SPARDIS Reference Number identification. <u>REL</u> - The Release control number for Reference. ⑤ (Bracketed fields) - These fields provide space for Production Foremen to manually enter his planning data regarding assignment of manpower, facilities, etc. ⑥ <u>UI</u> - Unit of Issue: The Ref. No.'s quantity/measurement factor. <u>QTY. REV.</u> - Quantity of Reference No. required & Revision of Ref. No. <u>SOURCE STOCK</u> - Indicates the Material Source required to produce Ref. No. <u>ITEM QTY</u> - Specifies the quantity of Source Stock to produce Ref. No.	⑦ <u>N/A</u> - Indicates the Next Assembly of Reference No. ⑧ <u>F/A</u> - Indicates the Final Assembly of the Next Assy. ⑨ <u>PRI OP</u> - Indicates the previous Work Station of Ref. No. ⑩ <u>COMPLETE DATE</u> - Specifies the scheduled completion date of Reference Number.
--	--

END

FIGURE 11



## Material Withdrawal Request (MWR)

The material withdrawal request system is a method by which purchased material is withdrawn from warehouses by production. It also provides a means by which the material requirements established in the SPARDIS system may be analyzed against total shipyard inventory and outstanding purchase orders.

The data in the MWR system is developed by extracting purchased material requirements from the WA/R File. These requirements, which are time phased, are first compared to the inventory on hand. This comparison begins by allocating the material on-hand to the requirements until the total on-hand quantity is consumed. At this point the Purchase Order File is examined and any outstanding purchase orders for the commodity are compared to the required quantities and their corresponding required dates. In this manner a set of data is generated from which a series of reports is created. Among these reports is an analysis of outstanding requirements by vendor, by commodity and by the production "Work package" (SPARDIS assembly). These reports form the basis of the material requirements planning (MRP) tools incorporated into the SPARDIS System.

The second phase of the MWR system deals with the actual withdrawal of material. As has been stated previously, this portion of the system is tied directly to the Shop Order. In developing shop orders for printing following a chase or parts explosion, a cross index to the WA/R file is developed. This cross index is developed for use of the teleprocessing system as a means of access to the WA/R data via the shop order number. The data being accessed, by way of the shop order number, is the same data as appears on the shop order. As part of the production process the production foreman examines his shop orders to determine which assemblies require purchased material. When he determines he is ready to proceed with the construction of an assembly, he simply requests the issue of material through the teleprocessing system. This request is then analyzed in relation to the material on-hand as described previously. The material is then obligated to the requested end-use and a withdrawal ticket printed by the computer. The withdrawal tickets are printed in such a manner that a group of commodities for a single assembly are printed by warehouse location. That is, if materials for a given assembly are located in more than one warehouse, then a separate ticket for each warehouse is printed. Separate documents are also prepared to allow for the staging or kitting of components from several warehouses. This permits the delivery of purchased components as a complete package of material to the appropriate work station, rather than the work station receiving a group of material from several warehouses and having to sort through the material to get the components they require for a specific job. This system is designed to permit a minimum amount of work-in-process and maximize the use of the data available for MRP. Since issues from the warehouse can be recorded in real-time, via the teleprocessing system, the inventory records tend to be more accurate than with "batch" systems.

Examples of several reports are presented in figures 12 thru 14. Figure 12 is a sample of one of the material analysis reports depicting commodities for which the material on-hand will be exceeded. Figure 13 is a sample of a material analysis report showing the assemblies scheduled that will be impacted by material shortages. Figure 14 is an example of an MWR ticket.

**FIGURE 12** (Page 1 of 3 pages)

PURPOSE: To provide a "tool" to review the planned processes for filling material requirements & to assist in material purchases, expediting and production release decision.

SCOPE: Exception report, listing those commodities for which the inventory on-hand in less than the requirements from the Chase process

FREQUENCY: Daily, and following the Preliminary & Final Chases.

REPORT Number: H 1 6 2 8

Title: MATERIAL SHORTAGE REPORT

DAILY - MATERIAL SHORTAGES REPORT - 1/3													04/13/76 05:27		PAGE 1	
MATL CODE	DESCRIPTION / SIZE	DATE	ON HAND ACT	PROJ	T	PO NO	ITM	SN	QTY	S / O	HUL REF NO - REL F / A - REL	QTY				
59-00-0853	STAT.OP.REMOTE.STOW#9879-RHMS 1" (8 TPI),STOW -517-16		0	0												
	PRIORITY-P	04-23-5	2-	2-	M				210965	393 R3-81	001 R2-63	001 2				
	PRIORITY-P	04-23-5	9-	9-	M				210989	393 R3-103	001 R2-74	001 7				
	PRIORITY-P	04-29-5	11-	11-	M				205037	393 R3-83	001 R2-64	001 2				
	PRIORITY-P	04-29-5	25-	25-	M				205070	393 R3-87	001 R2-66	001 14				
	PRIORITY-P	04-29-5	27-	27-	M				205095	393 R3-101	001 R2-73	001 2				
		02-05-6	27-	20-	M	R03198	001		7							
		02-05-6	27-	18-	M	R03207	001		2							
		02-05-6	27-	16-	M	R03284	001		2							
		02-05-6	27-	14-	M	R03287	001		2							
		02-05-6	27-	0	M	R03525	002		14							
		02-05-6	27-	1	M	R03791	007		1							
59-00-0854	STAT.OP.REMOTE.STOW#9879-RHMS 1" (16 TPI),STOW -534-16		0	0												
	OBLIGATED-X	04-24-5	6	6	M				210924	393 R3-59	001 R2-53	001 2				
	OBLIGATED-X	03-04-6	4	4	M				908764	393 R3-87	800 R3-87	800 2				
	OBLIGATED-X	03-04-6	0	0	M				908765	393 R3-50	800 R3-50	800 4				
	PRIORITY-P	03-04-6	2-	2-	M				908766	393 R3-41	800 R3-41	800 2				
		02-05-6	2-	0	M	R02871	004		2							
		02-05-6	2-	1	M	R03832	001		1							

- ⑦ ON ORDER: - Details all pending NASSCO Purchase Orders for Material Code:  
PO NO - NASSCO Purchase Order number.  
ITM - The Item (or Line) number on the Purchase Order that the Material Code appears.  
SN - Multiple-shipment designator (01, 02, 03, etc.). Used when a vendor promises to ship specified qtls of the Material Code on different dates.  
QTY - The quantity of Material Code ordered on the Purchase Order.
- ⑧ (Date & Time) - The actual date and time that this particular computer print-out was made.

(Continued on next page)

**PURPOSE:** To provide a "tool" to review the planned processes for filling material requirements & to assist in material purchases, expediting and production release decisions.

**SCOPE:** Exception report, listing those commodities for which the inventory on-hand is less than the requirements from the Chase process

**FREQUENCY:**  
Daily, and  
following the  
Preliminary &  
Final Chases.

REPORT Number: M1628Title: MATERIAL SHORTAGE REPORT

DAILY - MATERIAL SHORTAGES REPORT - 1/5															04/13/76 05:27		PAGE 15	
①	②	③	④	⑤	⑥	⑦	⑧	⑨										
M1628																		
WATL CODE	DESCRIPTION / SIZE	DATE	ON HAND ACT	PROJ	C	ON ORDER	QTY	S / O	HUL	REF NO	REL P / A	REL	QTY					
59-00-0853	STAT.OP.REMOTE.STOW#9879-RHMS 1" (9 TPI).STOW -517-16																	
	PRIORITY-P	04-23-5	0	0	M			210965	393	R3-61	001	R2-63	001	2				
	PRIORITY-P	04-23-5	9	9	M			210989	393	R3-103	001	R2-74	001	7				
	PRIORITY-P	04-29-5	11	11	M			205037	393	R3-63	001	R2-64	001	2				
	PRIORITY-P	04-29-5	25	25	M			205070	393	R3-67	001	R2-66	001	14				
	PRIORITY-P	04-29-5	27	27	M			205095	393	R3-101	001	R2-73	001	2				
		02-05-6	27	20	M	R03198	001	7										
		02-05-6	27	18	M	R03207	001	2										
		02-05-6	27	16	M	R03264	001	2										
		02-05-6	27	14	M	R03267	001	2										
		02-05-6	27	0	M	R03525	002	14										
		02-05-6	27	1	M	R03791	007	1										
59-00-0854	STAT.OP.REMOTE.STOW#9879-RHMS 1" (16 TPI).STOW -534-16																	
	OBLIGATED-X	04-24-5	8	8	M			210924	393	R3-59	001	R2-53	001	2				
	OBLIGATED-X	03-04-6	4	4	M			908764	393	R3-67	800	R3-67	800	2				
	OBLIGATED-X	03-04-6	0	0	M			908765	393	R3-50	800	R3-50	800	4				
	PRIORITY-P	03-04-6	2	2	M			908766	393	R3-41	800	R3-41	800	2				
		02-05-6	2	0	M	R02871	004	2										
		02-05-6	2	1	M	R03832	001	1										

9 REQUIREMENTS: = Details all active WA/R File commitments for Material Code for Reference Items:

S / O = The Production Shop Order number on which the Material Code is listed.

HUL = Specifies the Hull number applicable to the Shop Order.

REF NO = The Part Number of Assembly Number which required the Material Code.

REL = The Release Number of the Reference Number.

P / A = Indicates the structured progressive movement of Reference Number, depending on one of the following criteria:

- If the Reference Number is a Sub-Level Assembly (Level 3,4,5,6,7), the structured Next (or Final) Assembly Number is indicated.
- If the Reference Number is a Level 8 or 9 Part Number - that does not have a cutting/ratio greater than 1:1; does not also/cut another part; and does not multiple-cut itself, the Next (or Final) Assembly Number is indicated.
- If the Reference Number is a Level 8 or 9 Part Number - which has a cutting/ratio greater than 1:1; also/cuts another part; or multiple-cuts itself, the Reference Number automatically becomes an Inventory Item - with the result that the Next (or Final) Assembly Number will be inhibited from "pegging" a next destination or movement and will simply repeat it's own Part Number in order to automatically generate its next movement to a storage area for subsequent staging and issue when actually required.

END

**PURPOSE:** To identify Assemblies which contain material shortages - so that they may be rescheduled, if necessary, by Production Planning.

**SCOPE:** Exception report, listing Assemblies which contain commodities for which the inventory on-hand is less than the total requirements for that commodity.

**FREQUENCY:**  
Daily, and  
following the  
Preliminary &  
Final Chases.

**REPORT Number:** M1630

**Title:** ASSEMBLIES WITH MATERIAL SHORTAGES

M1630 ASSEMBLIES WITH MATERIAL SHORTAGES - DAILY 04/13/76 05:33 PAGE 35														
C	HULL	F / A	REL	N / A	REL	REF	REL	S / O	S	MTL CODE	QTY	DT REQ	W/S	NXT W/S
V	388	B2-23	001	B2-23	001	B2-23	001	339851	2	98-00-0150	1	01-20-6	101	030 P-SHORT
V	388	B2-24	001	B2-24	001	B2-24	001	339855	2	98-00-0150	1	01-20-6	101	030 P-SHORT
V	388	B2-36	001	B2-36	001	B2-36	001	318708	2	98-00-1600	1	12-31-5	101	030 P-SHORT
V	388	B2-387	001	B2-387	001	B2-387	001	355773	4	50-00-0680	16	02-23-6	101	030
									2	51-00-0578	16	02-23-6	101	030
									4	55-00-0107	16	02-23-6	101	030
									2	98-00-0300	2	02-23-6	101	030 SHORTAGE
V	388	B2-82	001	B2-82	001	B2-82	001	355804	2	98-00-3050	1	02-23-6	101	030 P-SHORT
V	388	C2-222	800	C2-222	800	C2-222	800	988948	4	50-00-0834	8	03-17-6	101	112 SHORTAGE
V	380	C2-368	001	C2-368	001	C2-368	001	369839	2	94-00-0080	3	03-31-6	101	112 SHORTAGE
									2	94-00-0055	3	03-31-6	101	112 SHORTAGE
V	388	C8-1069	001	C8-1069	001	C8-1069	001	393734	2	83-00-7978	1	05-04-6	002	077 SHORTAGE
V	388	K2-168	001	K2-168	001	K2-168	001	371794	2	98-00-5017	12	03-29-6	101	471 SHORTAGE

- ① C - NASSCO-assigned Contract identification code.  
HULL - NASSCO-assigned Hull identification number.  
F / A - Indicates the Final Assembly for which the material is destined.  
REL - Specifies the Release Number of the Final Assembly for which the material has been allocated.
- ② N / A - Indicates the Next Assembly for which the material is destined.  
REL - The Release Number of the Next Assembly for which the material has been allocated.
- ③ REF - The Reference Item that appears on the Shop Order number.  
REL - The Release Number of the Reference Item that is printed on the Shop Order.  
S / O - The Shop Order number containing the Reference Item detailing.
- ④ S - Denotes the Source Item Material Code number which specifies NASSCO's method of material acquisition.  
MTL CODE - NASSCO-assigned Material Code identification number.  
QTY - Specifies the quantity of Material Code required for Reference Number.  
DT REQ - Indicates the date that the Material Code must be delivered to Production.
- ⑤ (Date & Time) - The actual date and time that this particular computer print-out was made.
- ⑥ W/S - Specifies the issuing Work Station that the Material Code is to be shipped from.  
NXT W/S - Indicates the next Work Station or Assembly area that the Reference Item is destined.
- ⑦ (Shortage flags) - This field indicates whether or not an item has a potential shortage based on the material analysis (see REPORT M1628). The word SHORTAGE indicates a potential shortage; the word P-SHORT indicates a potential shortage that has been selected for high issue priority.

END

FIGURE 13

<b>PURPOSE:</b>  To provide a printed hard-copy document that authorizes issue of purchased components to Production.	<b>SCOPE:</b>  Assures control of both the issue and in-house delivery point of all components.	<b>FREQUENCY:</b>  Daily.	<b>REPORT Number:</b> MWR  <b>Title:</b> MATERIAL WITHDRAWAL REQUEST
---	---	---------------------------------	--

98

98

① HSE P
② MATERIAL WITHDRAWAL REQUEST
③ AREA: A
④ SHOP ORDER 376524-5 CD 1

⑤ RMG:100-027
REF NO:A9-10065
REL:001
REQ'D:04-19-76
HULL:388
PGE:01-01

⑥ TA:072
LOC:PLT SHOP PRE-FAB: STEEL PLATE (6 PLT C/F).
INV TYPE:INV STA

⑦	ISS	REQ. UI	PCE MARK	MAT'L CODE	DESCRIPTION	LOC.
	1 EA	02-0593	02-00-0593	PL A	15.3#X115X246	

⑧	CONTR	REFERENCE NO.	REL NO.	LNE NO.	CK. CODE	MATL PREP
	V	A9-10065	001	000	140	B-B

⑨ CTL APPROVED \_\_\_\_\_
DATE \_\_\_\_\_
⑪ \*LAST PAGE - END OF PACKAGE\*

⑩ WR PRINT DATE 03/28/76
ISS'D \_\_\_\_\_
DATE \_\_\_\_\_
REC'D \_\_\_\_\_
DATE \_\_\_\_\_
⑫

<p>① <u>WISE</u> - Specifies the Warehouse/Storage facility that will issue the Material Code (Piece Mark).</p> <p>② <u>AREA</u> - Designated the in-house delivery point that the Warehouse will ship the Material Code (Piece Mark).</p> <p>③ <u>SHOP ORDER</u> = The MHR SHOP ORDER control number.</p> <p>④ <u>CD</u> - Card Code Check Digit. A computer-generated Check Code - intended to negate an improper on-line update.</p> <p>⑤ <u>DRWG</u> - The blueprint (Drawing) that the Reference Number can be viewed.</p> <p><u>REF No.</u> - NASSCO-assigned Reference Number identification.</p> <p><u>REL</u> - The Release control number for Reference Number.</p> <p><u>REQ</u> - Date that the Reference Number is required at Production.</p> <p><u>HULL</u> - NASSCO-assigned Hull identification code.</p> <p><u>PCE</u> - Indicates the number of contiguous pages and sets constituting this complete MWR: The first 2 digits = Page number; the second 2 digits = Set number.</p>	<p>⑥ <u>STA</u> - The Work station that the Material Code (Piece Mark) is to be shipped to.</p> <p><u>LOC</u> - Description of the receiving Work Station.</p> <p><u>INV TYPE</u> - Specifies the category or type of NASSCO'S Material Control Inventory system.</p> <p>⑦ <u>ISS</u> - This "blank" field is used by the issuing Work Station to manually write-in the <u>actual</u> quantity of Material Code (Piece Mark) issued; the manually entered qty is then updated on-line for accounting/inventory control.</p> <p><u>REQ</u> - Indicated the qty of Material Code (Piece Mark) that is required to produce the Reference Number.</p> <p><u>UI</u> - Unit of Issue. The Piece Mark's measurement/qty factor</p> <p><u>PCE MARK</u> - Piece Mark: The Material Code Number assigned to the Piece being issued.</p>
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(Continued on next page)

FIGURE 14 (Page 1 of 2 pages)

PURPOSE:  To provide a printed hard-copy document that authorizes issue of purchased components to Production.	scope  Assured control of both the issue and in-house delivery point of all components.	FREQUENCY:  Daily.	REPORT Number: <u>MWR</u>
		TITLE <u>MATERIAL WITHDRAWAL REQUEST</u>	

① WHSE P MATERIAL WITHDRAWAL REQUEST AREA: A SHOP ORDER 376524-5 CD 1

⑤ DRWG:100-027 REF NO:A9-10065 REL:001 REQ'D:04-19-76 HULL:388 PGE:01-01

⑥ STA:072 LOC:PLT SHOP PRE-FAB: STEEL PLATE (6 PLT C/F). INV TYPE:INV STA

⑦ { ISS. REQ. UT PCE MARK MAT'L CODE DESCRIPTION LOC.

1 EA 82-0593 82-00-0593 PL A 15.3#X115X246

⑧ { CONTR REFERENCE REL LNE CK. MATL  
NO. NO. NO. CODE PREP

V A9-10065 001 000 140 B-B

⑨ MCTL APPROVED \_\_\_\_\_ DATE \_\_\_\_\_ \*LAST PAGE - END OF PACKAGE\*

⑩ MWR PRINT DATE 03/28/76 ISS'D \_\_\_\_\_ DATE \_\_\_\_\_ REC'D \_\_\_\_\_ DATE \_\_\_\_\_

⑪

- ⑦ (Continued)
- MAT'L CODE = NASSCO-assigned 10-digit material identification code.
- DESCRIPTION = Detailed description of the Material Code.
- LOC = Indicates the storage location of the Material Code in the Warehouse or storage facility.
- ⑧ CONTR = NASSCO-assigned Contract identification symbol.
- REFERENCE NO. = SPARDIS Reference Number identification.
- REL NO. = The Release control number for Reference Number.
- LNE NO. = Line Item Number of the Reference Number's structure.
- CK, CODE = A computer-generated Check Code to insure that on-line updating of Warehouse issuance of the Piece Mark material for the proper Contract & Reference Number is correct.
- MATL PREP = Material Preparation Code: Symbols define the special type of raw material surface preparation (cleaning, paint, etc.) that must be made before issuance of the Piece Mark to the first receiving Work Station.

- ⑨ MCTL APPROVED = The Material Control Department must manually verify and authorize issuance and proper assignment of Material Code(s) indicated on each MWR prior to forwarding the MWR to the issuing Warehouse or storage facility.
- ⑩ MWR PRINT DATE = The date that the computer printed the MWR.
- ISS'D / DATE = The name of employee in the Warehouse that issued the material & the date of issue.
- ⑪ LAST PAGE ... = Indicates that this is the last Page of this MWR SHOP ORDER Number.
- ⑫ REC'D / DATE = The name of employee at the delivery point or receiving area for this particular Warehouse shipment.

END

FIGURE 14 (Page 2 of 2 pages)

## SUMMARY

SPARDIS is a tool for planning and controlling the shipbuilding task. It is designed to permit management the visibility to one of the company's greatest resources, information. It allows management the ability to make intelligent decisions based on the latest status of the shipyard. It permits long range planning to be accomplished as well as the everyday detail release of work for the shipyard. To accomplish this SPARDIS uses a common data base concept. The common data base consists of five data files:

Description

Structure

Routing

Schedule

and created from these is the

Work Authorized/Released

The WA/R File generates reports for management and is used to release work to the shipyard. All other files in the SPARDIS System are generated from these "Master Files" for ease of access to this data base through the **teleprocessing system.**

As work is completed in the shipyard the data base is user updated on line, via remote terminals to provide:

Component history

Accurate audit trail

Completion status

Storage location (s)

In addition to the teleprocessing, system management reports are generated in a routine manner. The types of reports generated are:

operational

Analysis

Exception

Additionally special reports are available on a request basis.

The concept of the SPARDIS teleprocessing system is that:

All files are on-line for data retrieval

Minimum of hard copy output



Principle method of data input

Data transmittal form optional as a back-up

Records are created in batch mode, data input and updated on-line.

Security feature of the teleprocessing system are established by allowing only certain terminals access to updating capability. Also certain check codes are created to ensure the proper record within a file is updated as well as the proper individual is performing the update. As part of the back-up system a series of transaction logs are maintained. The teleprocessing system in use at NASSCO has an average access time of between 5 and 10 seconds.

It should be re-emphasized that SPARDIS is nothing more than a tool. It is the user of the tool that allows the company to build ships in today's competitive shipbuilding environment.

## SPADES SYSTEM CURRENT DEVELOPMENTS

Albrecht Schulze  
Cali and Associates  
Metairie, Louisiana

Mr. Schulze has ten years of experience in applying electronic data processing techniques to shipbuilding. At Cali and Associates he is responsible for developing new software in this area.

For enhancement of the 'SPADES' System, three new modules are currently planned and under development:

1. Ship Production and Control Module (SPAC). A management information system which utilizes the information collected on the 'SPADES' data base.
2. Detail Engineering Module (DEMO). A module that is designed not only to produce engineering drawings, but to aid in data collection and consequent loading of the data base with information generated by the Engineering Department.
3. Pipe Length and End-Cuts Program (PLEC). A special program to aid in fabrication of complex three-dimensional pipe structures, which is of special interest to manufacturers of oil rig structures.

Like all other modules of 'SPADES', these new modules will directly access the 'SPADES' data base, utilizing information that has been generated by other modules, and in turn making available to the other modules information gathered by it. Thus, information is collected and stored where it is generated. There will be no need to recreate information by other departments downstream with the duplication of effort and a high probability of errors. The three new modules will continue the expansion of 'SPADES' from an N/C manufacturing method to a computer-controlled information flow throughout the entire design and construction period.

# " S P A D E S ' S Y S T E M

## SHIP PRODUCTION & CONTROL MODULE

{Preliminary Description}

### INTRODUCTION

The use of extensive modular construction in shipbuilding, combined with the increased use of Numerical Control, has greatly improved in the last decade the efficiency of the industry.

In order to properly utilize these techniques, it was immediately apparent, however, that more and better planning was necessary.

The planning effort, per se, is neither too difficult nor too costly. The collection and updating of the data needed to generate the required reports is both difficult and costly in order to obtain a reasonable degree of accuracy.

The 'Ship Production and Control (SPAC) Module' of the 'SPADES' System is designed to achieve in this area the following goals:

1. Reduce man-hours for data collection.
2. Improve the accuracy and timeliness of the reports.
3. Reduce ship construction costs by reducing errors and misinformation in the shops.

The 'SPAC' Module covers at the present only the hull construction. It is intended that, in parallel with the development of modules to handle the design and production of other ships' systems, the 'SPAC' Module will be expanded accordingly.

## DESIGN CRITERIA OF THE 'SPAC' MODULE

Since the 'SPAC' Module properly falls in the category of management information systems, the basic criteria applicable to this type of system must be respected as follows:

1. The module must allow the collection of independent data at the origination source and make it immediately available to all interested shipyard functions.

As an example, for instance, assembly boundaries and schedule starts can be inputted directly to the system and the 'master erection schedule' report generated immediately after for dissemination.

2. All applicable data generated by other modules of 'SPADES' must be collected and used by the 'SPAC' Module without any user intervention.

This feature is the main justification for the development of the module, and the following is a partial list of examples:

1 Allocation to the proper assembly and sub-assembly of all pieces generated through use of 'PARTGEN', 'PARTSEP', 'PLATDV', or MANF AID' (frame bending).

- Processing time for N/C burning tapes and flame planer sketches.

ŽUnit weight of individual pieces and weight and centers of gravity of assemblies and sub-assemblies.

- Length and nesting within standard lengths of shapes of the various individual shape pieces.

ŽCross reference between assemblies due to the nesting into a plate of pieces belonging to different assemblies.

ŽBulk material allocation for pieces produced through shearing or 'one-to-one' optical burning.

3. Revision control is maintained by the system for all the issued reports generated.

A summary report can also be generated, showing at any one point in time the current valid revisions of all the issued reports.

4. Any change of the independent data or other data used by the system must generate an exception report indicating which of the reports are affected by the change, so that the user can initiate the proper request.

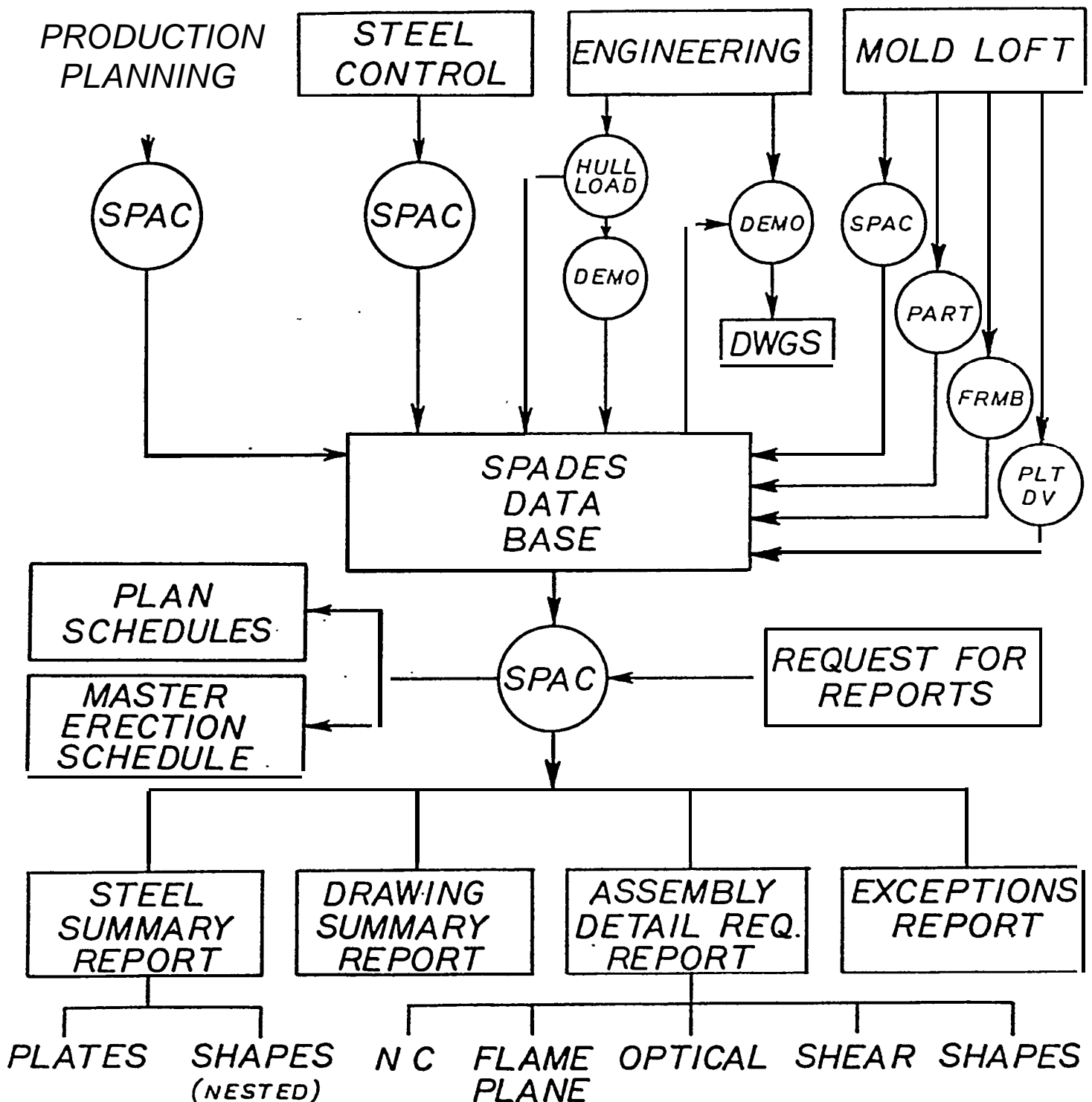
For example, if planning changes require different boundaries for any one assembly, the module must automatically update the allocation of all pieces effected by the change of boundaries, and give a report indicating which reports must be requested for re-issue.

5. Exception reports can be generated to indicate to the user at any point in time which pieces for any one particular drawing have not as yet been defined, or any material deficiencies.
6. The system must allow the introduction of data at levels other than the optimum, to override or enrich the data base, in order to be able to generate complete reports at any time.

The following pages contain the basic data flow for the module, a brief description of the input needed, and some examples of the reports generated by the system. The examples of the reports are simulated in this preliminary description, and they will be changed as the development of the module proceeds.

# SPADES SYSTEM

## DATA FLOW FOR SHIP PRODUCTION AND CONTROL MODUL



TYPES OF INPUT & RESPONSIBILITY FOR  
THEIR PREPARATION BY SHIPYARD FUNCTION

1. Production Planning

- a) Limiting boundaries of planned assemblies (units) and sub-assembly breakdown, if any. The system will always assume that a ship's surface, such as deck, webs or shell will constitute a sub-assembly.
- b) Planned start date for processing each assembly.

2. Steel Control

- a) Final steel bill. This is intended to mean the steel take-off bill as modified for utilization of stock and/or standardization of plate size. The various items in the various steel bills will carry a unique stock number compatible with the shipyard system.
- b) Storage location of various items in the steel bill will be given to the system upon receipt of the steel.

3. Engineering

- a) Loading of the data base. Through the detail engineering module, the data base loading capabilities will be expanded, allowing at the same time the easy generation of detail drawings. As part of this activity, engineering will also update, as needed, data base libraries of standards (brackets, chocks, etc. ), shapes, characteristics, and associated cut-outs.
- b) Drawing list and associated range of pc. mks. used in each drawing. This will allow the system to generate exception reports calling attention to pieces not generated at any one point in time.

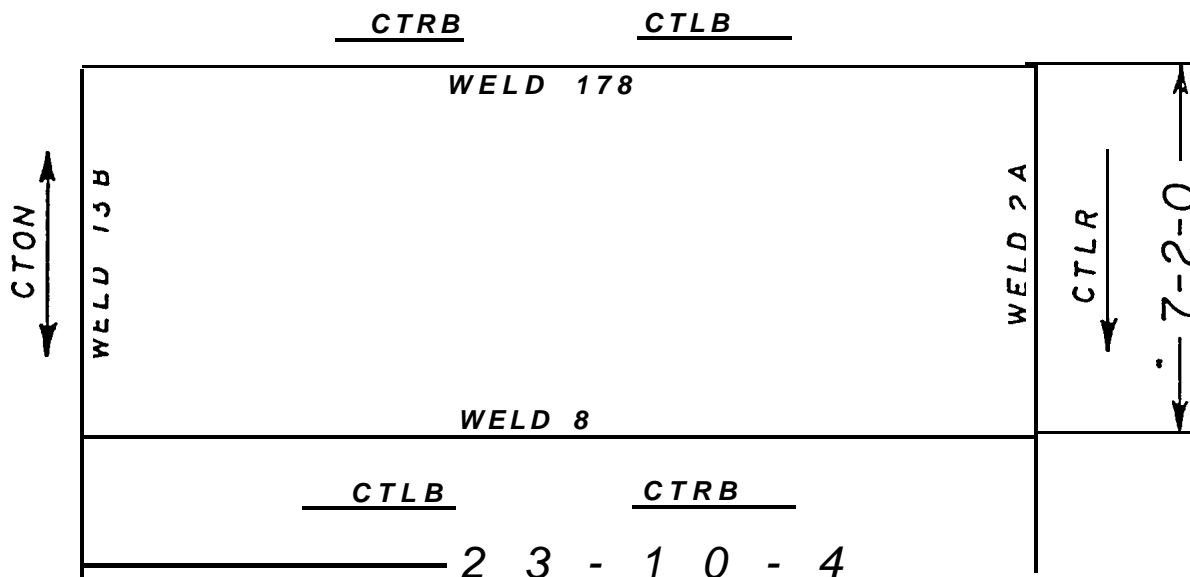
4. Mold Loft

- a) Through the use of 'PARTGEN', 'PARTSEP' and 'PLATDV', the loft will enable the system to allocate the pieces thusly generated to the various assemblies and sub-assemblies. Provision will be made for identifying drawings, pc. mk. and beveling detail, and also applicability of a part to another area of the ship.



SHIPYARD NAME  
EXACTOGRAPH SKETCH

SHIP \_\_\_\_\_ HULL NO. \_\_\_\_\_  
JOB ORDER NO. \_\_\_\_\_  
ASSEMBLY \_\_\_\_\_  
SUB ASSEMBLY \_\_\_\_\_  
DWG. NO. \_\_\_\_\_ PC. NO. \_\_\_\_\_ DET NO. \_\_\_\_\_  
PLATE SIZE \_\_\_\_\_ QTY REQD. —  
PLATE STOCK NO. \_\_\_\_\_



+ TAPE NO. 301376 - 307 - 1 EXACTOGRAPH

DATE 12/11/75

JOB C6A1

SPADES SYSTEM

SHIP PRODUCTION AND CONTROL MODULE

ASSEMBLY INFORMATION

ASSEMBLY 302

PAGE 1.1\*

REV. 2

ASSEMBLY DESCRIPTION: INNERBOTTOM FR. 46-50 STBD. INCLUDING SHELL, FLOORS, GIRDERS AND TANK TOP

ASSEMBLY BOUNDARIES: VERTICAL (X) FROM B.L. TO SEAM F (J F)  
HORIZONTAL (Y) FROM C.L. TO SHELL STBD. (M)  
LONGITUDINAL (Z) FROM 1.0 FT. FWD. FR. 46 TO 1.25 FT. AFT FR. 50

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ASSEMBLY WEIGHT & C.G.: WEIGHT: 63.5 LT VCG: 2.87 FT. TCG: 17.67 FT. LCG: 1.33 FT. AFT FR. 48

SCHEDULED START DATE: 4/15/76

LIST OF SUB-ASSEMBLIES

SUB-ASSEMBLY NO.	SURFACE NAME	DESCRIPTION
302 - 1	M	SHELL STRAKES B & C
302 - 2	F 49000	FLOOR O.B. L.G. 6
302 - 2	F 49500	FLOOR O.B. L.G. 6
302 - 2	F 50000	FLOOR O.B. L.G. 6
302 - 3	D TT	TANK TOP

LIST OF APPLICABLE DRAWINGS FOR ASSEMBLY 302

LINE	DRWG. NO.	REV.	ISSUE DATE	TITLE
1	S11 - 3 - 3	4	4/15/75	FLOORS FR. 32 TO FR. 60
2	S11 - 4 - 2	3	3/21/75	T.T. PLTG. FR. 32 TO FR. 60
3	S11 - 1 - 2	2	1/21/75	SHELL PLTG. FR. 32 TO FR. 60.
4	S11 - 6 - 2	3	2/1/75	CVK AND LONGL. GDRS. FR. 32-60

DATE 12/11/75JOB C6A1

## SPADES SYSTEM

'PAGE 2.1\*

## SHIP PRODUCTION AND CONTROL MODULE

REV. 2

## MATERIAL LIST FOR ASSEMBLY 302

## STEEL PLATES

LINE	STOCK NO.	GRADE	SIZE	QTY.	'X-REF.	TAPE / SK	PRC. TIME	STOR, LOC.
1		ABS -MILD	40 x 8 x .75	4'	NOTE 1	N/C-388001-1	125 MIN.	B-13
2		HY -80	37 X 9 X 1.00	2		SK 301376 -307-1	24 MIN.	C-7
3		ABS-MILD	40 x 8 x .5	1		SHEAR/OT		B-6
4		ABS -MILD	42 x 9 x .5	2	NOTE 2	N/C 311752- 1	109 MIN.	D-3

NOTES :

1. PROCESSING THIS TAPE WILL PRODUCE PIECES FOR ASSY(S) 304, 417.
2. THIS TAPE SHOULD HAVE ALREADY BEEN PROCESSED WITH ASSY. 301.

DATE 12/11/75JOB C6A1

## SPADES SYSTEM

PAGE 3. 1\*

## SHIP PRODUCTION AND CONTROL MODULE

REV. 2

## STEEL SHAPES

LINE	STOCK NO.	GRADE	SIZE	LENGTH	QTY.	LINE NO. OF NESTED PIECES	STOR. LOC.
1		ABS - MILD	T9 x 4 x 21.30 <sup>#</sup>	40	16	2, 7, 9	M - 3
2		ABS - MILD	T9 x 4 x 21.30 <sup>#</sup>	40	4	2, 6, 10, 12	M - 3
3		ABS - MILD	I/T9 x4 x 17.50 <sup>#</sup>	26	1	8	M - 5
4		ABS - MILD	W/F10 X 10 X 77 <sup>#</sup>	40	2	37	M - 6
5		ABS - MILD	L6 x 4 x 13 <sup>#</sup>	40	4	4	M - 1
6		ABS - MILD	I12 x 5 x 35 <sup>#</sup>	40	1	1	M-17
7		ABS-MILD	T8 x 4 x 13 <sup>#</sup>	22	2	5	L -4

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SPADES SYSTEM  
SHIP PRODUCTION AND CONTROL MODULE

PAGE 4.1\*  
REV. 2

DETAIL LISTING OF REQUIRED PIEGES FOR ASSEMBLY 302

PIECES PRODUCED THROOUGH N/C CUTTING

LINE	SUB-ASSY	DRWG; NO.	PC. NO.	DET.	STD. PC. NO.	MAT. REF.	QTY.	UN. WT.	ADD .PROCESS.	TEMPLATES
1	302-1	S11-1-2	17	5-B		2, 1-1	4		ROLL	388002 -402-1 388002 -403-1 388002 -404-1
2	302-3	S11-4-2	25	4-C		2, 1-4	2	7275#		
3	302-3	S11.4-2		-	5007		20			
4	302-2	s11-3-3	73	11-C	5220		2			

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JOB C6A1

S PADES SYSTEM  
SHIP PRODUCTION AND CONTROL MODULE

PAGE 5.1\*  
REV. 2

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PIECES PRODUCED THROUGH FLAME PLANER

LINE	SUB-ASSY	DRWG. NO:	PC: NO.	DET.	STD. PC: NO.	MAT. REF.	QTY.	UN. WT.	ADD.ROCESS,	TEMPLATES
1	302-1	S11.1-2	2	4 -A		2, 1-2	2	3488#		

DATE 12/11/75  
JOB C6A1

SPADES SYSTEM  
SHIP PRODUCTION AND CONTROL MODULE

PAGE 6.1 \*  
REV .

PIECES PRODUCED THROUGH OPTICAL CUTTING

IINE	SUB-ASSY	DRWG. NO:	PC. NO;	DET.	STD. PC. NO.	MAT. REF.	QTY.	UN. WT.	ADD; PROCESS.	TEMPLATES
*** NONE THIS ASSEMBLY * * *										

DATE 12/11/75JOB C6A1S P A D E S   S Y S T E M  
SHIP PRODUCTION   ND CONTROL MODULE

PAGE 8.1\*

REV. 2

## PIECES PRODUCED FROM SHAPES

LINE	SUB-ASSY	DRWG.NO.	PC. MK.	DET.	STD. MK.	MAT.REF.	QTY.	UN.WT.	CUT LENGTH.	ADD.PR.	TEMPLATES
1	302-1	S11-1-2	57	5-A		3.1-6	1	271#	7-9-3(F)		
2	302-1	S11-1-2	58	5-A		3.1-1	20	261#	12-3-4		
3	302-1	S11-1-2	59	5-A		3.1-4	2	2811#	36-6-0(E)		
4	302-1	S11-1-2	60	5-A		3.1-5	4	390#	30-0-0	FRMBND	384005-402-2
5	302-3	S11-4-2	25	4-C		3.1-7	2	469#	36-1-0(F)		385005-402-2

DATE 12/11/75JOB C6A1S P A D E S   S Y S T E M  
SHIP PRODUCTION AND CONTROL MODULE

PAGE 7.1\*

REV. 2

## PIECES PRODUCED THROUGH SHEARING

LINE	SUB-ASSY	DRWG.NO.	PC. NO.	DET.	STD. PC. NO.	MAT. REF.	QTY.	UN.WT.	ADD. PROCESS.	TEMPLATES
1	302-3	S11-4-2	77	2-C		2.1-3	1	653#		

- b) Through the use of 'MANFAID' (frame bending), all shapes, whether straight or curved, will be identified and allocated to the proper assembly. The Frame Bending Program will be modified to easily do that for all flat surfaces.
- c) Through the use of the Ship Production and Control (SPAC) Module, the loft will input to the System all the miscellaneous pieces not otherwise identified.

# ' S P A D E S '      S Y S T E M

## ENGINEERING    DETAILING    MODULE

### Preliminary Description

( DEMO )

### ' OBJECTIVES

The main purpose of this module is to utilize the time and effort spent during the detail design phase for numerical description of the ship structure. During this phase, all structural details are defined; and if these definitions can be recorded on the data base, interpretation of the drawing and the possibility of errors downstream during part generation can be greatly reduced. Greatly expanded data base loading capabilities will provide information over and above the geometrical part generation requirements which can be used by the planning and control module or other ship's systems.

As the volume of information on the data base increases and the data base becomes more comprehensive, verification of loaded data becomes more and more difficult. The quickest way of verification is by drawing. Therefore, a simple and easy way of accessing the data base with a few commands is needed to automatically output all loaded data of a particular surface into a composite drawing.

If this drawing capability is achieved, only a few options are needed to extract partial drawings for all kinds of purposes. Structural drawings can be complete with the exception of lettering and dimensioning. Background drawings for arrangements and composites can be produced with just a few commands.

### PREREQUISITES

In order to make this module an efficient tool for detailing, the loading capabilities of the data base will be expanded. The 'HULLLOAD' Module will be capable of loading traces and details in transverse, plan and elevation views. Additional information on all surfaces will include:

- a) Stiffeners and their end connections
- b) Seams and plate thickness associated
- c) Brackets and chocks
- d) All access holes, including face bars
- e) Inside contours, as defined by web frames.

All through members affecting other surfaces must be handled by 'HULLLOAD' .  
Local details will be defined by 'DEMO'.

## OPERATING PROCEDURE

Although the module's primary task is to aid in loading the data base, direct loading capability is not conceived. The actual loading of the data base is reserved for the group of people responsible for loading the data base through 'HULLLOAD'. This is to preserve the integrity of the data base by concentrating the responsibility onto one person, or one group of people. However, to avoid having the 'HULLLOAD' people recode all the definitions, Module 'HULLLOAD' will have the capability of executing the same input decks, ignoring irrelevant commands, but executing and loading the detail specifications.

The application of the module within the ship design effort is seen as follows:

1. Fairing and loading of the major structure through 'HULLLOAD'.
2. Extract a drawing of the surface containing outlines and through members through 'DEMO'.
3. Load repetitive patterns of stiffeners and seams through 'HULLLOAD'.
4. Extract a new drawing through 'DEMO' containing all loaded details.
5. With 'DEMO' , add and modify details of stiffeners, seams, holes and brackets, resulting in:
  - . A new drawing, complete with the exception of lettering and dimensioning
  - . An input deck defining the details executable by 'HULLLOAD'
  - . An entry in a data base record which contains all input decks that are generated by 'DEMO' and must be executed by 'HULLLOAD'
6. When the design is completed, control is transferred to 'HULLLOAD'. The input deck is executed, loading the details. The entry of the final step above is deleted.
7. Revisions:
  - a) If the drawing is not released as yet, the revision may be added to the 'DEMO' input deck executing '5' and '6'.
  - b) If the drawing is released and lettering and dimensioning has been added, revisions are effected through 'HULLLOAD' only.
8. After the structural details have been loaded, drawings for other disciplines such as arrangements and composites may be called.



INFORMATION   DEFINED   BY   'DEMO'

Only local details are defined through 'DEMO' . Details are defined as follows:

1. Stiffeners:      Symbolic name            S   ABC   P/S  
                         Contour definition  
                         Shape code number  
                         Orientation (near side or far side)  
                         End connections (lap, snipes, knuckles).
2. Seams:           Symbolic name            J   ABC   P/S  
                         contour definition  
                         Welding detail (bevel and gap)  
                         Thickness on both sides.
3. Holes:            Symbolic name            H   123   P/S  
                         Contour definition  
                         Thickness, width and off set of face bar.
4. Brackets:        Symbolic name            B   123   P/S  
                         Contour definition or standard detail identification  
                         Thickness  
                         Width and thickness of flange.
5. Inner Lines:      Accessible only as a contour  
                         Identified by 'LNNL'  
                         Contour definition  
                         Width and thickness of face bar.

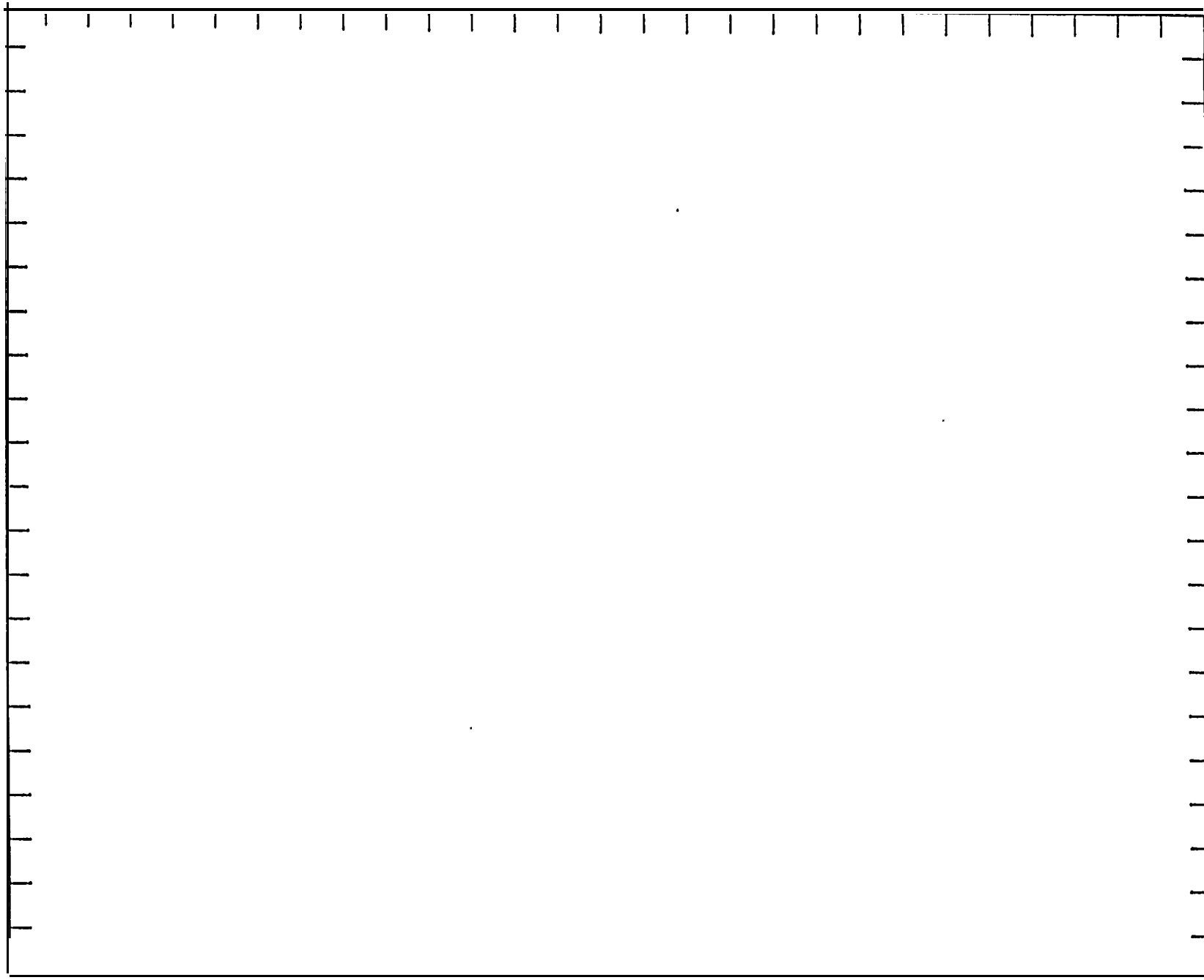
## PROGRAM CAPABILITIES

1. options with automatic drawing Of data base contents:
  - a) Scales
  - b) Windowing
  - c) With or without shapes ('T', 'L', etc. )
  - d) With or without cut-outs and snipes
  - e) With or without stiffeners and seams on the surface
  - f) Include background frame or deck
  - g) Pen selection for turret machines
  - h) Line selections of different types of dashed lines.
2. .Automatically included as drawing standard:
  - a) A standard grid surrounding the entire drawing
  - b) Center line and/or base line, if part of the drawing.
3. Programming capabilities and language as close to 'PARTGEN' as possible, so that people programming 'PARTGEN' and 'DEMO' are interchangeable. . All 'PARTGEN' tools such as Math, Contours, Symbolic Calls, Loops and Reps will be available.
4. Added Commands for detail definition:
  - a) STIF
  - b) SEAM
  - c) HOLD
  - d) BRKT
  - e) INNL
5. Looping capability:

Programming of similar surfaces by modification to typical surface such that only changes have to be redefined.

Fig. 1

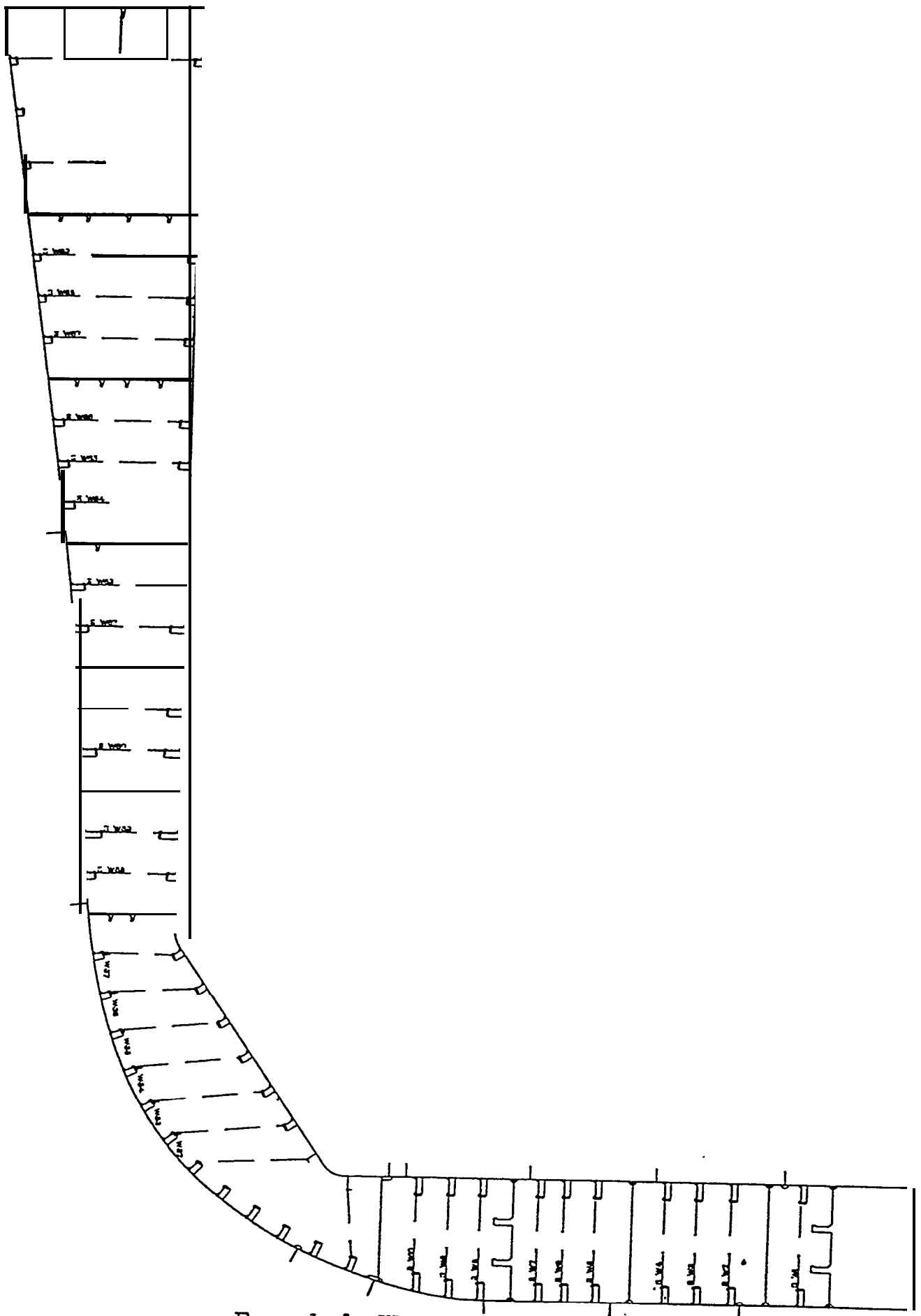
120



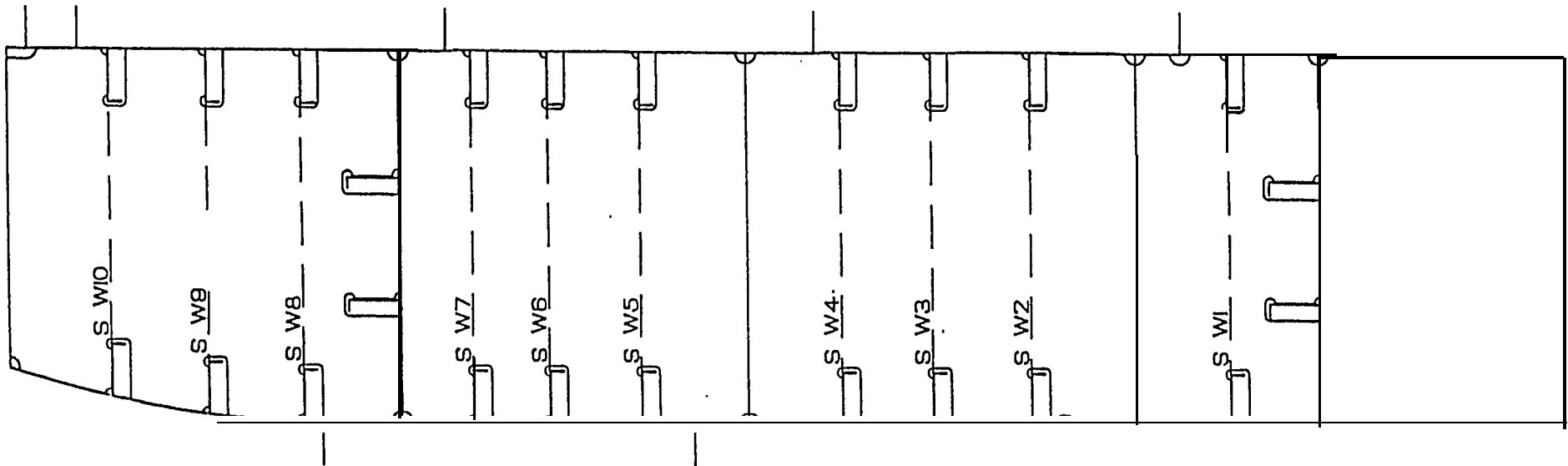
+

TAPE NO. 203002 - 1

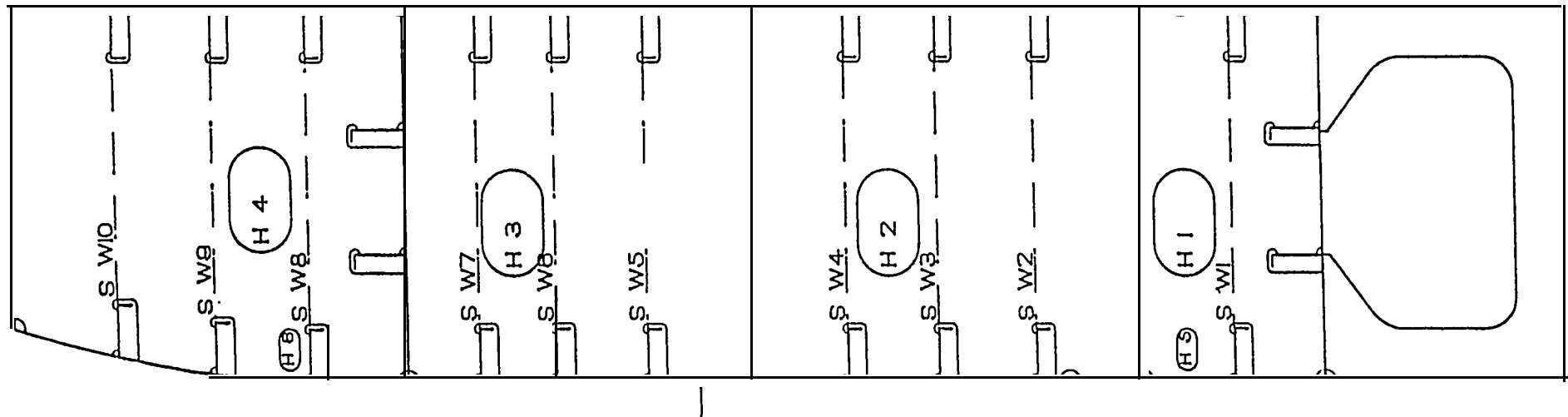
Standard Grid for All Drawings



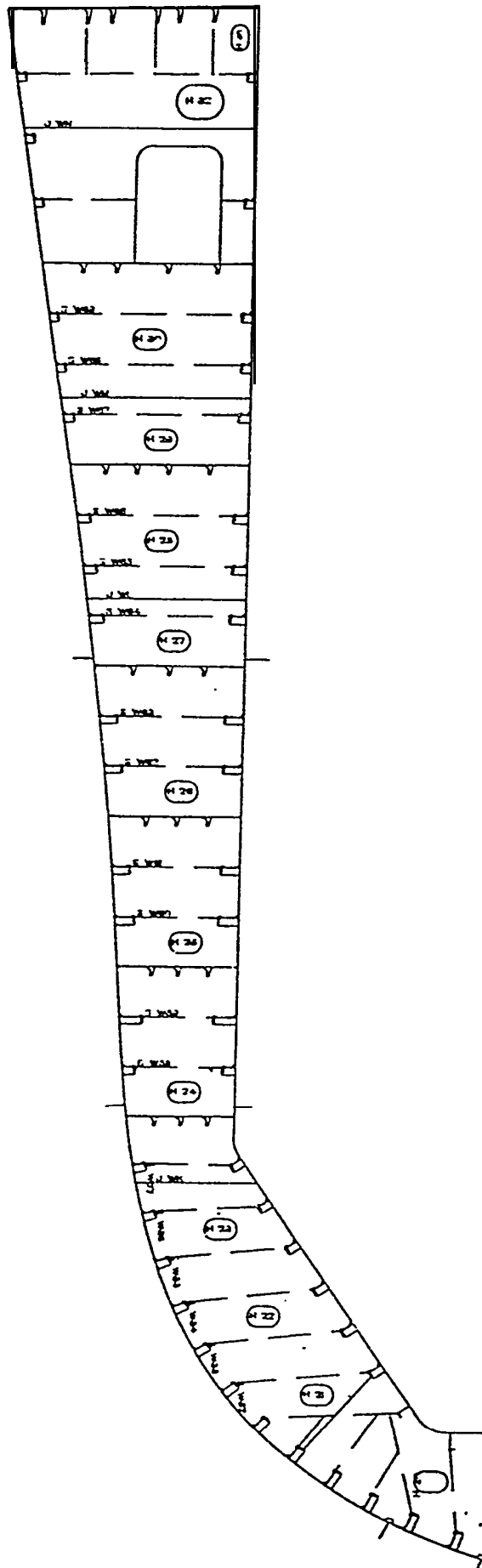
Example 1: Webframe 52  
Drawing after 'HULLLOAD' only



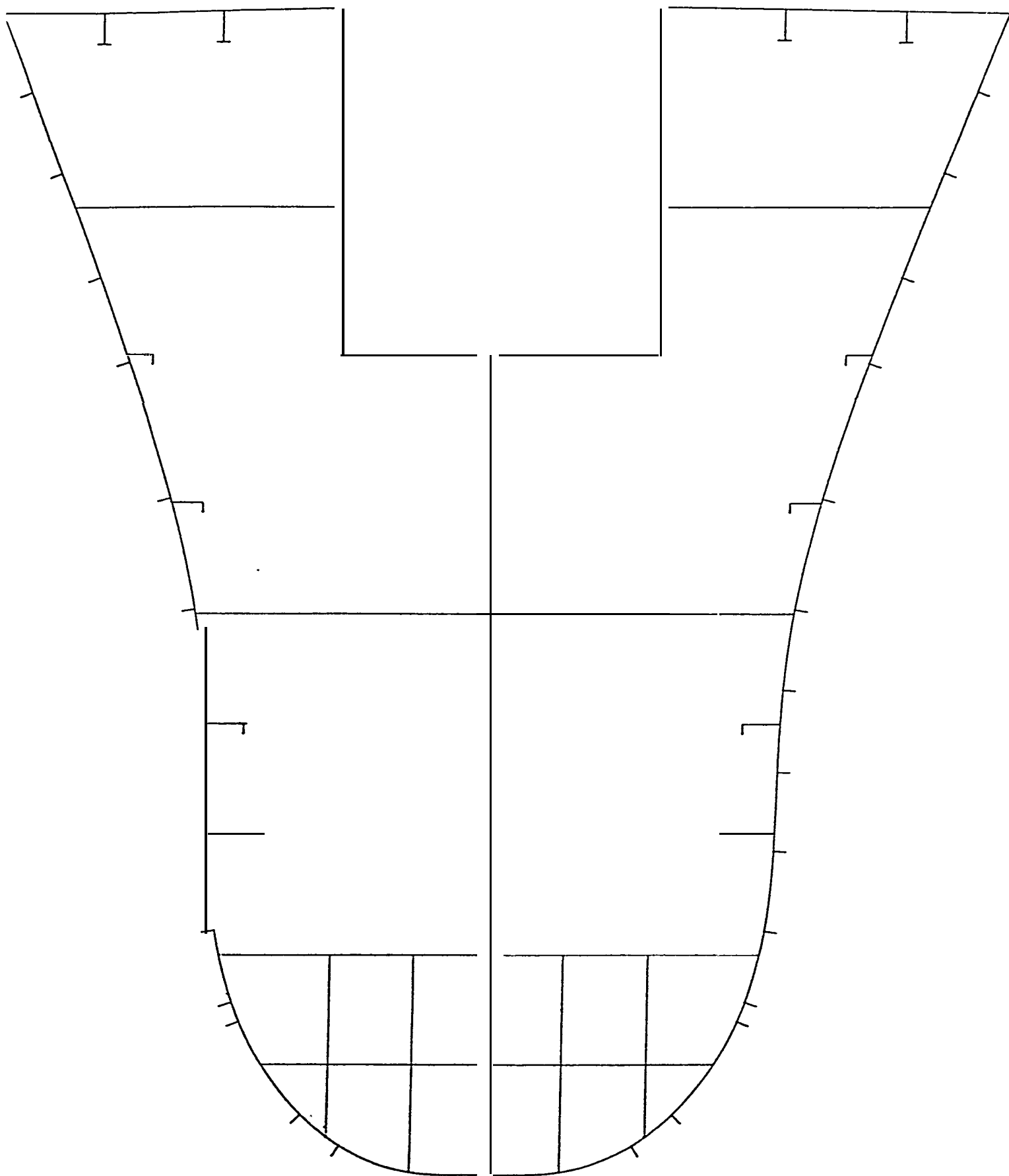
Example 1: Floor 52  
Drawing after 'HULLLOAD' only



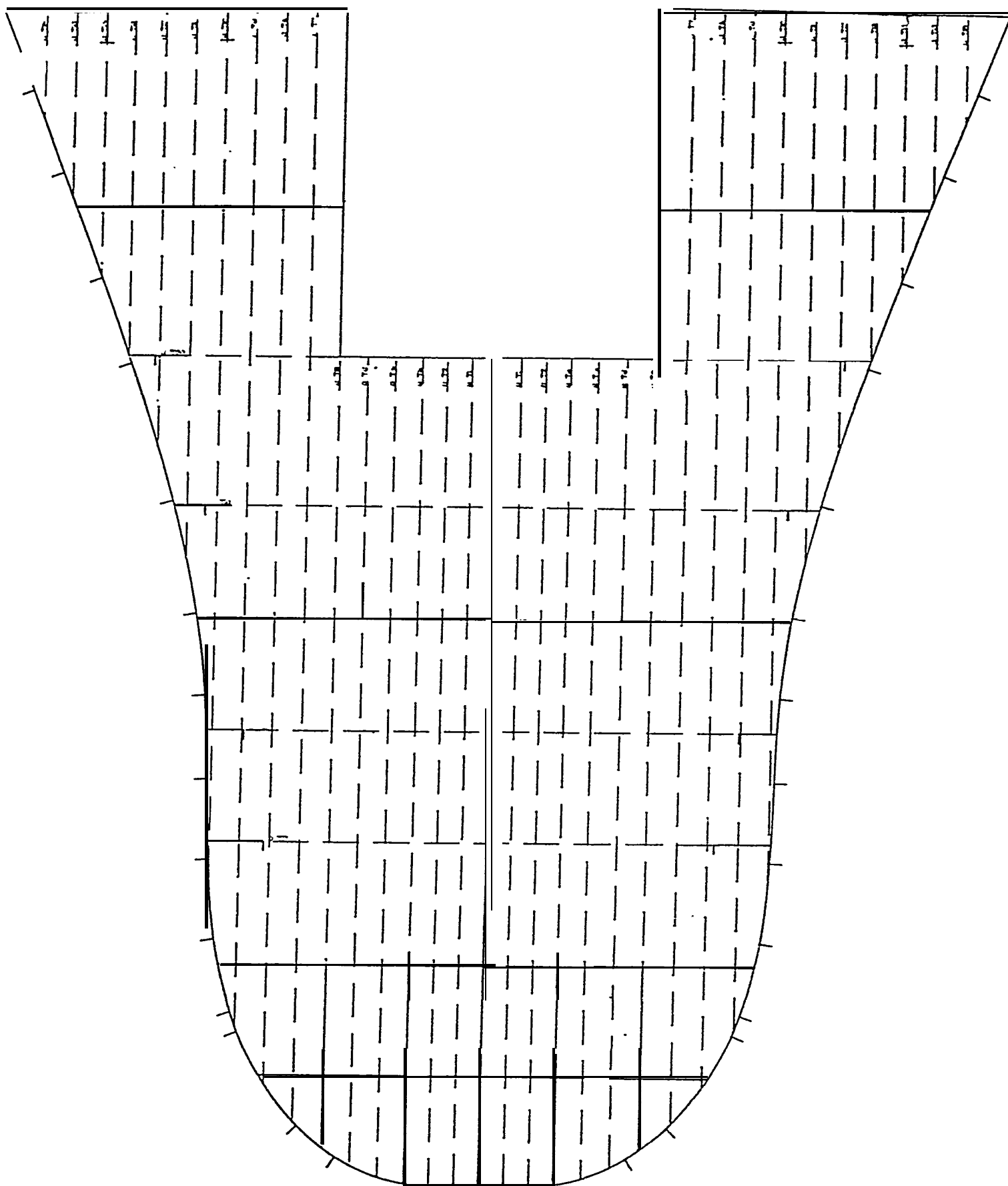
Example 1: Floor 52  
Drawing after detailing by 'DEMO'.



Example 1 . Window of Webframe 52  
after detailing by 'DEMO'

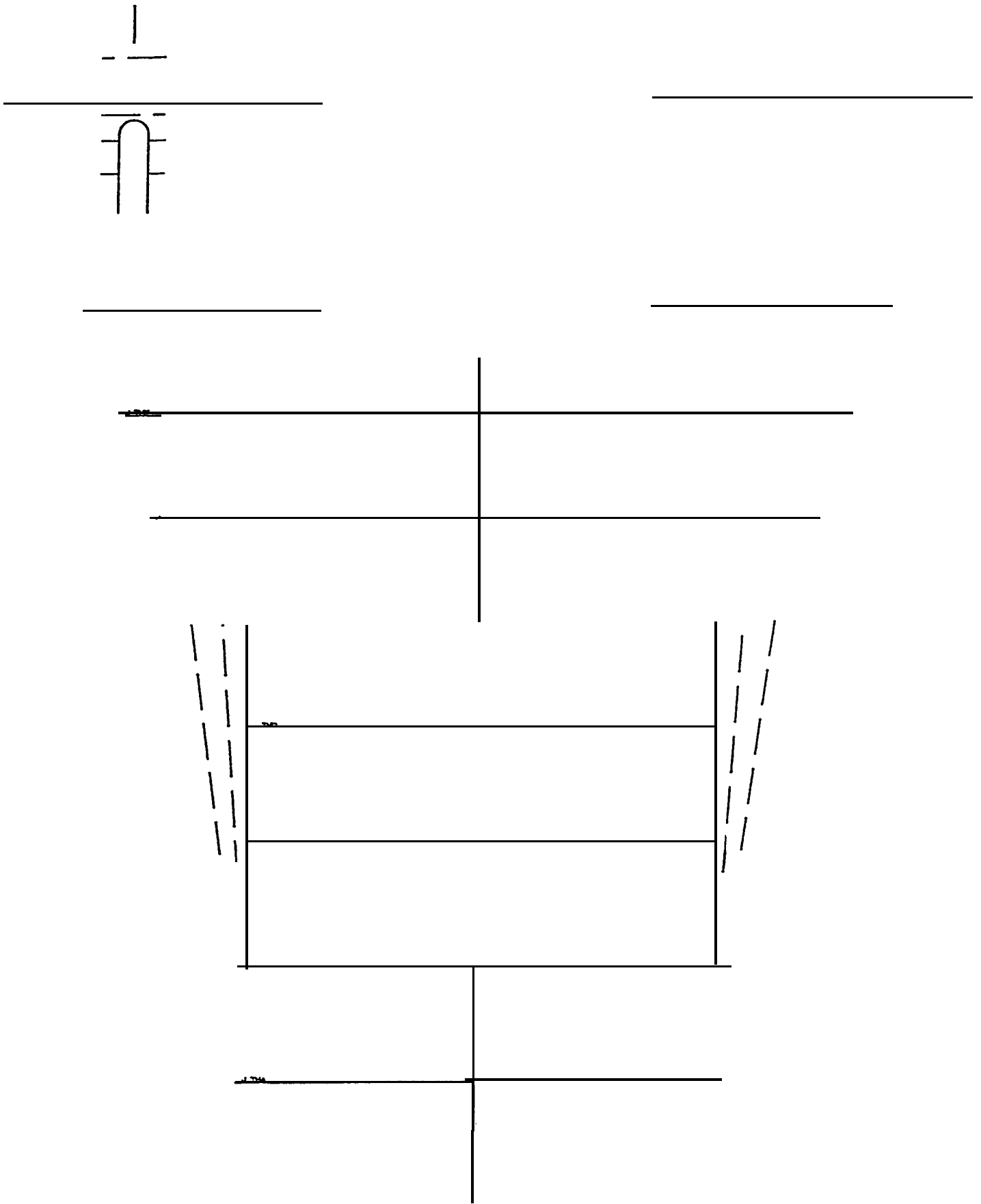


Example 2: Bulkhead 31  
 Drawing of major structure after 'HULLLOAD'  
 124 only.

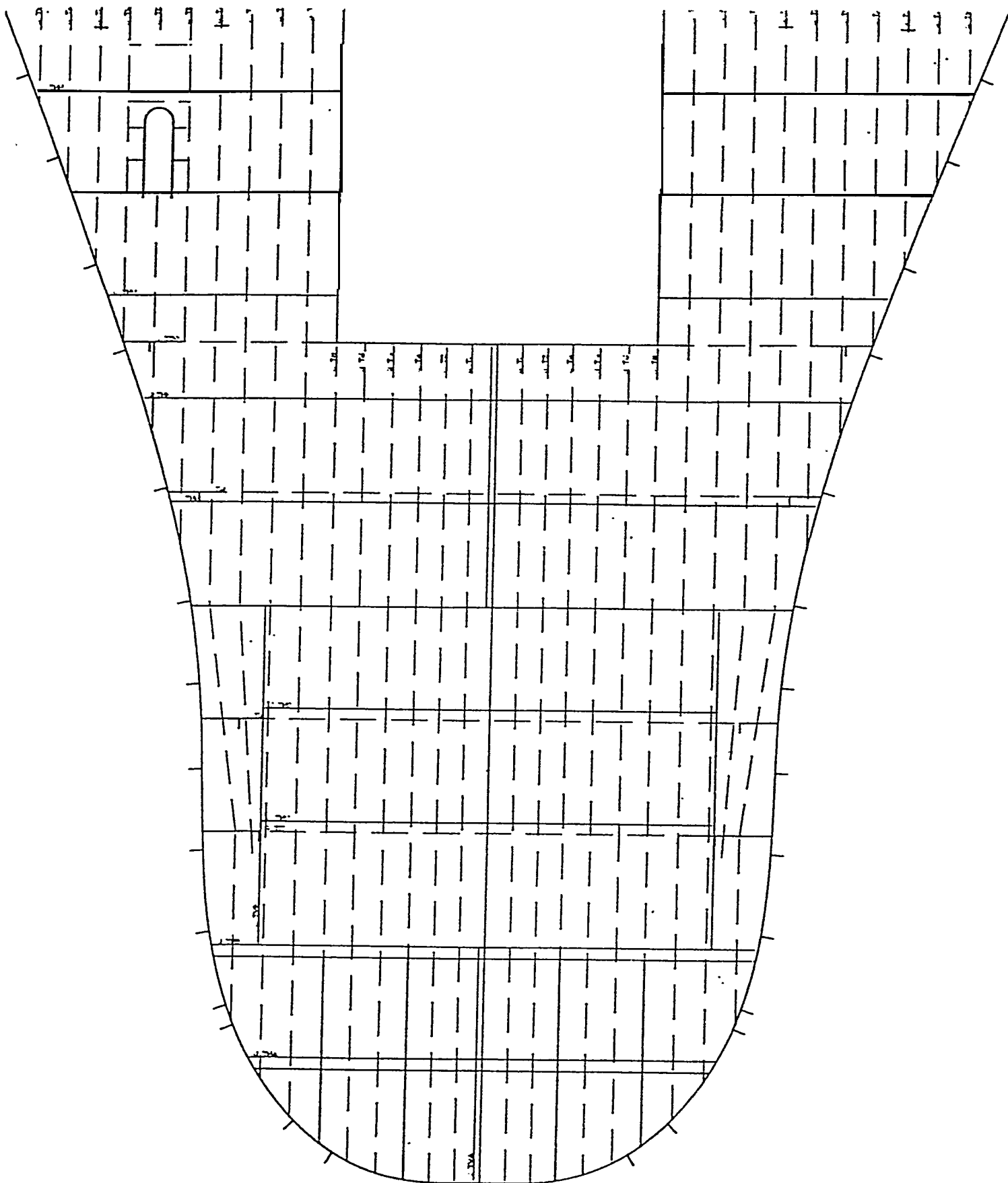


Example 2: Bulkhead 31  
Drawing of loaded details after 'HULLLOAD'





Example 2: Bulkhead 31  
Details programmed in 'DEMO'



Example 2: Bulkhead 31  
Final drawing after detailing by 'DEMO'

# ' S P A D E S '      S Y S T E M

## PIPE   LENGTH   AND   END-CUTS   PROGRAM

( P L E C )

### PROGRAM   DESCRIPTION

#### 1. PROGRAM   CAPABILITIES

The Pipe Length and End- Cuts (PLEC) Development Program allows the user to simply define a complex three-dimensional pipe structure and extract for each member all data necessary for its fabrication.

It is designed to accurately determine the length and shape of end-cuts of a straight cylinder (pipe) terminating at both ends into or penetrating through one or more of the following surfaces:

- Straight cylinder with identical or different diameter and with or without axial eccentricity.
- Curved cylinder, as in above.
- Cone, with or without axial eccentricity
- Plane inclined at any angle .
- Sphere with or without eccentricity.

Within this context, the term 'eccentricity' is used to indicate the case when the two axes are not contained in the same plane. For the sphere cylinder intersection, eccentricity means that the center of the sphere does not lay on the axis of the cylinder.

In the generation of data, allowance will be made to include the slots needed for through brackets or collars.

The data generated by the program can be outputted in any one of the formats described below, subject to the following limitations:

- Tabulation Format. This option is always available and allows in all cases the manual plotting of templates or layout on the surfaces.

- Ž Template Format. This option, subject to the availability of a drafting machine, is always available, except in the case of the penetration cut on a sphere or curved cylinder, since the development into a flat template is possible.

- Ž N/C Paper Tape. This option is available for all cases compatible with availability and capability of the N/C cutting machine.

## 2. INPUT HANDLING

As for all modules of the 'SPADES' System, all input will be permanently stored in the data base, and the standard 'SPADES' update facility is available for changes or revisions.

The input data required by the 'PLEC' Program can be divided in two categories:

### a. Definition Input

This type of input is used to define a three-dimensional structure.

The definition includes the three-dimensional location of all joints and the characteristics of any member between any two joints.

The input language is such that location of all joints can be done utilizing dimensions, angles and units of measure (including metric) as given in the design drawings. As an aid to check the validity of the input data, the program will generate a tabulation of the processed

data; and if a drafting machine is available, a drawing at the appropriate scale of the orthogonal views of the structure.

b. Execution Input

This type of input causes the program to generate the appropriate form of output needed to fabricate any member previously defined through definition input or whose definition is contained therein.

3. OUTPUT HANDLING

All output tapes (drafting or cutting machine) and tabulations will be stored permanently in the data base for back-up and later recall similarly to all 'SPADES' modules.

Revision control will be active for all outputs in order to ensure at all times the use of the correct tabulation, template or tape. In addition, the program will generate a printout containing all pertinent messages to the user, such as diagnostic error code and information messages relating to:

- Input data manuscript number and revision
- Output generated ID. number and revision
- Minimum cut-length of pipe stock needed
- Distance between bases (reference lines) for machine indexing or template application
- Processing time required to cut the pipe in the cutting machine
- Other erection information such as 'crawl' dimensions and angles.

The weight of each member will be computed and added to the member sketch;

The output data will be, at the user's option, in one or more of the following formats:

a. Tabulation

For those users without a drafting machine or a numerical control

pipe cutting machine, this output option gives all numerical data to make wrap -around templates, cut the pipe to correct length, and get the desired bevel.

**b. Templates by Drafting Machine**

This form of output will generate a paper tape for a drafting machine to draw the necessary wrap-around templates.

The end-cut templates for pipe members will be of the following types:

- Outside wrap-around with inside layout
- Outside wrap-around with both inside and outside layout. Either the inside or outside layout will be modified to reflect the required bevel, if any.
- Either of the above two developed on half thickness diameter rather than wrap-around for application prior to rolling of plate.

Any of the above can be set as a default option specified by the user.

The end - cut templates for beam members will contain the cut contours for both web and flange(s).

Each template will be automatically sectionalized to suit the size of the drafting machine available to the user and will contain appropriate reference lines for longitudinal and angular orientation of the template, Length of pipe and distance between reference markings will also be indicated on the templates.

A dimensioned sketch of the member will also be generated through the drafting machine, indicating as requested in each case, long/short to long/short length and length between reference markings. Length of transition and thickness changes will also be indicated.

c. Paper Tape for N/C Pipe Cutting Machine

This option will allow the user to generate a paper tape to cut the pipe with the desired bevel under numerical control. The tape will be totally compatible with the cutting machine and will allow as automated an operation as the machine is capable of.

The user will be responsible for furnishing to 'Cali & Associates, Inc.' all necessary and applicable information related to machine capability and tape format required by the N/C director.

Since 'PLEC' will be integrated with the 'SPADES' System, all general management and control features will be implemented.

4. ADDITIONAL FEATURES EFFECTED BY OTHER 'SPADES' MODULES

a. 'PARTGEN' Modification

Modify 'PARTGEN' to access the records loaded by 'PLEC' in order to allow easy development of any pipe related structure, whether internal or external to the pipe. Additional comamands will be added as needed for this purpose.

b. 'HULLCAL' Modification

Modify 'HULLCAL' to access the records loaded by 'PLEC' containing the geometrical description of the pipe structure. Add routines to 'HULLCAL' to handle the specific geometry of the pipe structure for inclusion in the calculations of all applicable 'HULLCAL' sub-programs.

AUTOKON'S APPROACH TO  
INTERACTIVE TESTING

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The paper presents a new approach to the problem of nesting of plane parts. The system developed is tailored for nesting of production parts for shipyards, more specifically those prepared by the AUTOKON 71/74 system. However, the general design is believed to be independent of any particular part-coding system or application.

Geometrically, the problem of nesting is a two-dimensional one, and it is basically similar to any jigsaw puzzle or two-dimensional cutting-stock problem if one disregards all the application considerations that constrain the solution.

The programs developed do not attempt any automatic optimization. The philosophy in designing the system has been that the user is capable of optimizing whatever his objective is, if only the computer is able to supply the appropriate information. Defining and applying the constraints required to do automatic nesting not only becomes difficult, it becomes impossible as constraints on the parts layout change dynamically.

The system was developed and is, so far, implemented on the Norwegian minicomputers NORD-10 and SM-4. The graphics display used is a Tektronix 4014-1 storage tube.

The system is designed to ease conversion to other computers and graphic displays and to interface to other part generation systems with or without databases.

What were the goals?

The purpose of this project was two-fold:

To develop an improved system for the nesting of steel plates,

To gain knowledge in the field of Computer Graphics.

By applying techniques in the Computer Graphics area we hoped to:

Reduce the amount of tedious noncreative and error prone work in the nesting process, and therefore maybe increase steel utilization.

Reduce the lead time which seems inherent in the nesting process (waiting to get the job back from the computer, from the drawing-machine).

Incorporate new functions which would be hard or difficult to perform in the manual system (certain types of common cut, manipulation on groups of parts, etc.).

Build a foundation for further development (such as part split, part coding general purpose drafting tools, etc.).

## Requirements

Certain major requirements were established at an early point of the specification phase. Some are listed, however, not necessarily in the order of importance.

The system must handle manually coded parts and parts prepared by a computer program (or more specifically the AUTOKON system).

The system must be able to handle an unlimited number of parts.

Functions must be available for displaying single parts (one or more at a time), formats being nested, and details on both of these. The user must be able to page through the part library.

The parts shall be identified and manipulated either by name or by means of a device pointing at the part image on the screen.

Parts should be displayed with lines drawn differently to distinguish between standard cutting, bevel cutting, common cutting, rapid traverses, punch marking and edge marking. The user must be able to select elements of a certain contour type, both for the purpose of displaying and for referencing.

The user must have functions to modify part production information, such as bevel cutting, common cutting, text, material handling number, thickness, steel quality etc. Functions to modify geometry are part of another module to be developed for part processing.

The user must have flexibility to perform all the basic transformations, translation, rotation, scaling and mirror-imaging, as well as actions combining these basic transformations.

The user must be able to make changes, to store away and to relate groups of nested parts or nested formats. This is important where certain constellations of parts, patterns, repeat.

The user must have functions to check the geometry of single parts or formats and nested formats. Overlap checks between single parts and neighbouring parts are also important to ensure a correct layout. Measurements must also be available.

The cutting sequence shall be specified by the user. The user must have freedom to start a new sequence and end a sequence wherever convenient.

A standard edited NC tape is to be the end product, or the NC information may be fed directly to a NC machine. The user may also store the NC information in the database.

The system must give quick and easily understood responses to all user actions. Production information that may influence the user's next action must at all times be available to the user.

#### System design

System specifications and programming considerations led to the conclusion that the system comprise three logically distinguishable jobs or phases of operation:

- data preparation and verification (DPREP)
- part layout (LAYUT)
- cutting sequence (CUSEQ)

#### Purpose of DPREP

The purpose of DPREP is to verify the parts in the database on the minicomputer and to prepare the parts for input to the LAYUT phase. Verification is achieved by displaying the part contours and associated production information (text) with the possibility of generating hard-copies. Data preparation involves reformatting and reorganizing data to meet hardware requirements and optimize data retrieval. (Number of accesses and access times to the database) and data enhancement to minimize core requirements and processing times.

#### Purpose of LAYUT

The purpose of LAYUT is to place parts together on a format or in a two-dimensional area, taking care of the geometry of what is going to be a nested format. Correcting and verifying completed formats or nested parts is also done in this phase of the system. The geometry of the nested parts will later be the input to the CUSEQ phase.

## Purpose of CUSEQ

The purpose of CUSEQ is to specify cutting sequence in order to optimize the use of the flamecutters (torches). The NC information produced is generated on papertape or fed directly to the flame-cutters. A copy of the nested format is stored on the database.

## System architecture

On the basis of the system design phase the following system architecture was arrived at (Figure 1).

All command input is handled by the Command Processor. Each Command is interpreted, the corresponding action routine is loaded from mass storage by the segmentation system (if not already in core), before the control is given to the routine. Upon all normal and abnormal (error) exits, control is returned to the Command Processor.

Each Action routine performs the operation specified by a specific command. To do so it utilizes the following service routines:

Nest 74 Service Routines provide general facilities needed by more than one action routine.

The Autobase Database System which administers the parts to be nested and system tables of different types.

Tektronix Driver. Routines for driving the Tektronix display.

## Hardware

The system Will be implemented on hardware shown in Figure 2, Where the absolute necessities are:

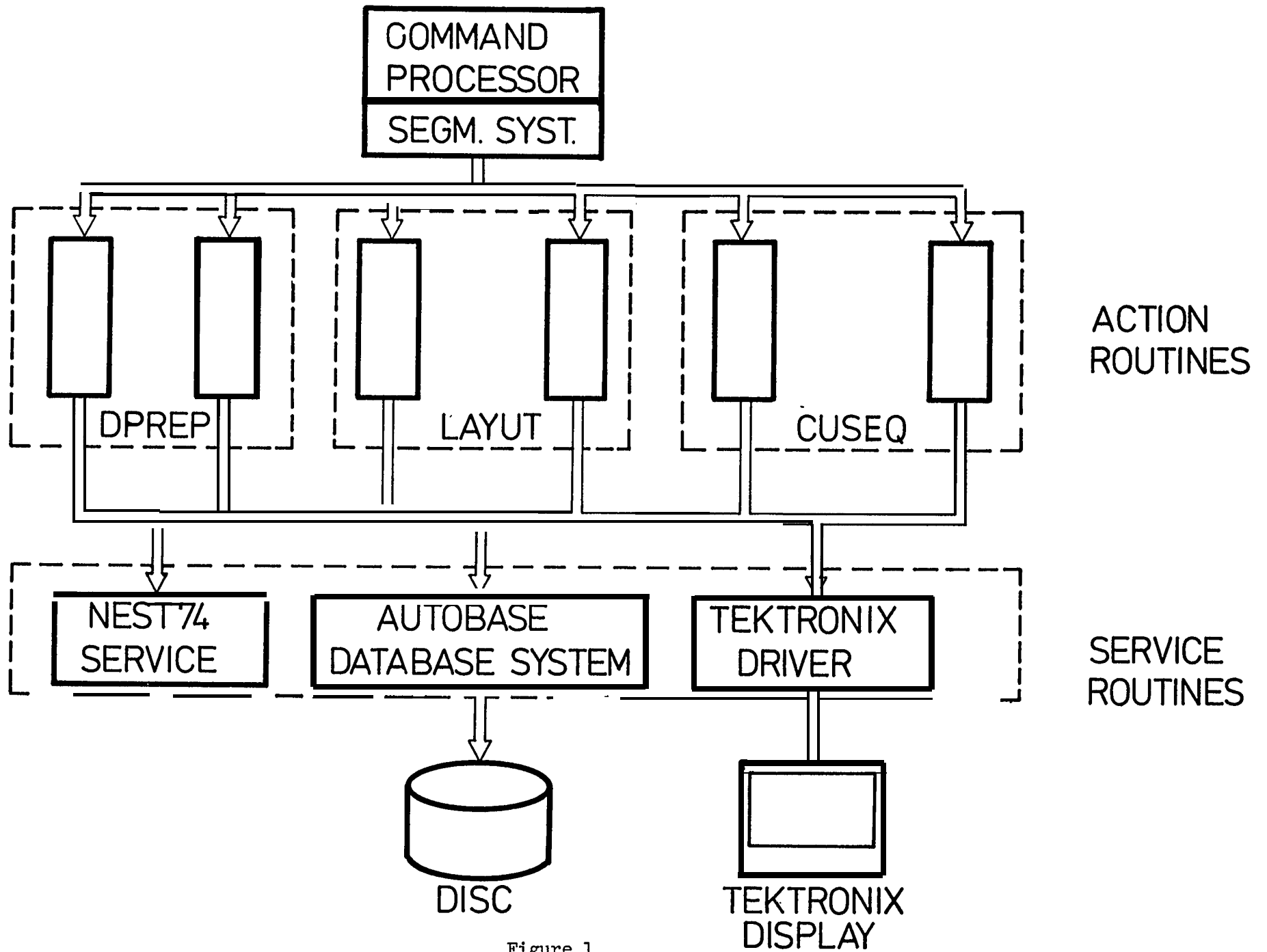


Figure 1

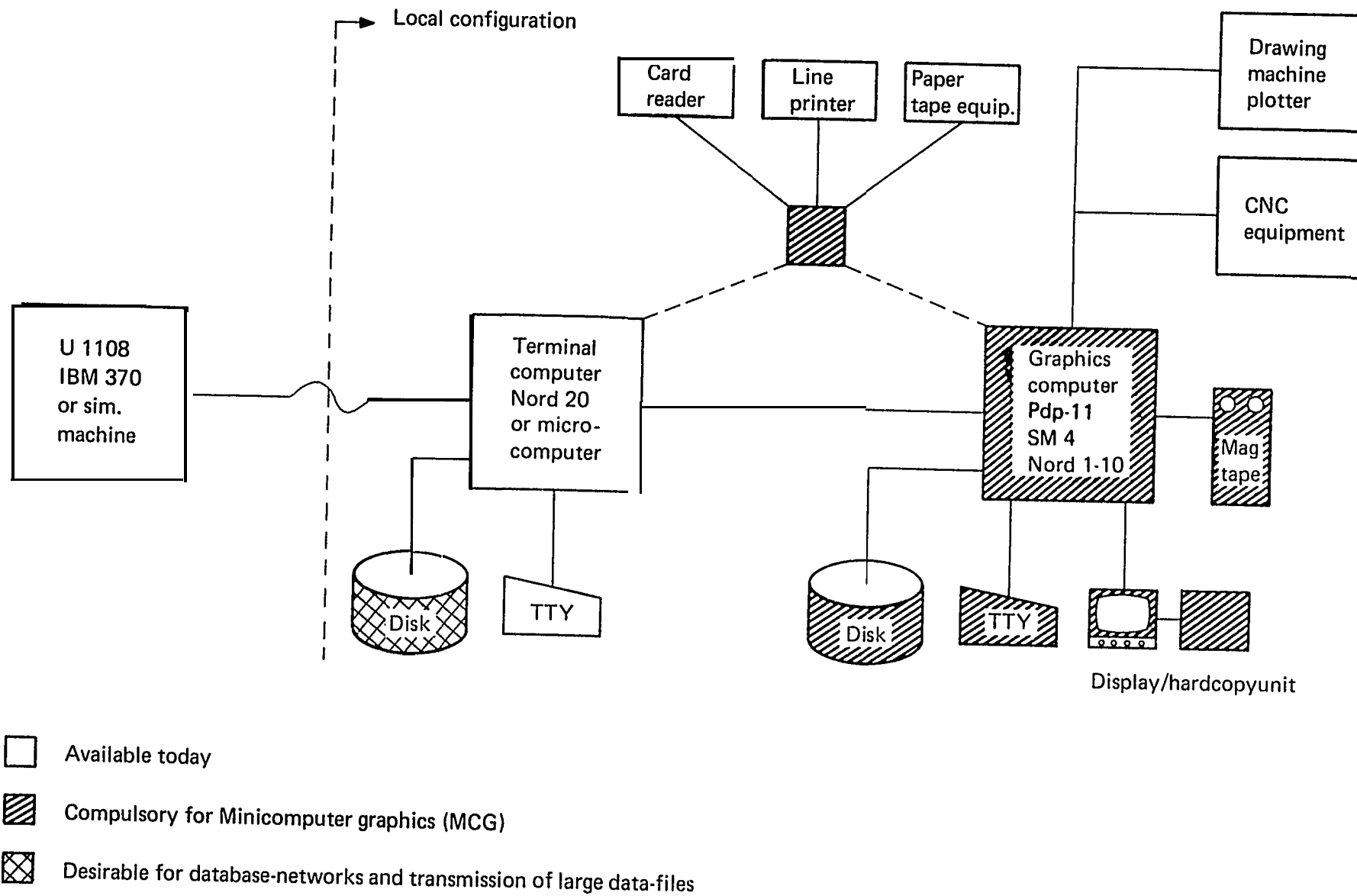


Figure 2

Minicomputer - (coresize dependent on program organization  
allowed by basic software - presently 48K).

Disc memory - preferably portable packs.

Tektronix 4014 - 1 Display terminal - hardcopy possibility provided.

Papertape reader/punch.

Teletype.

If the parts are generated on another system a direct connection between the other system and the minicomputer is desirable (Figure 2).

Program and data flow (Fig. 3).

Before the nesting system may be started a database must be built on the minicomputer. This system assumes that the user will work with parts from one section at a time although parts from different sections may be mixed.

The part record in the minicomputer database should contain some information which has previously not been included for AUTOKON, such as:

Cutouts along the outer contour and holes should be marked such that the smooth silhouette contour may be readily retrieved.

Kerf width compensations and shrinkage should be allowed for before the part is used in the DPREP phase.

Once a database of parts is established the DPREP phase may be started. DPREP, upon user request, reads all the pertinent information for a part to be nested, from the part records on the minicomputer database.



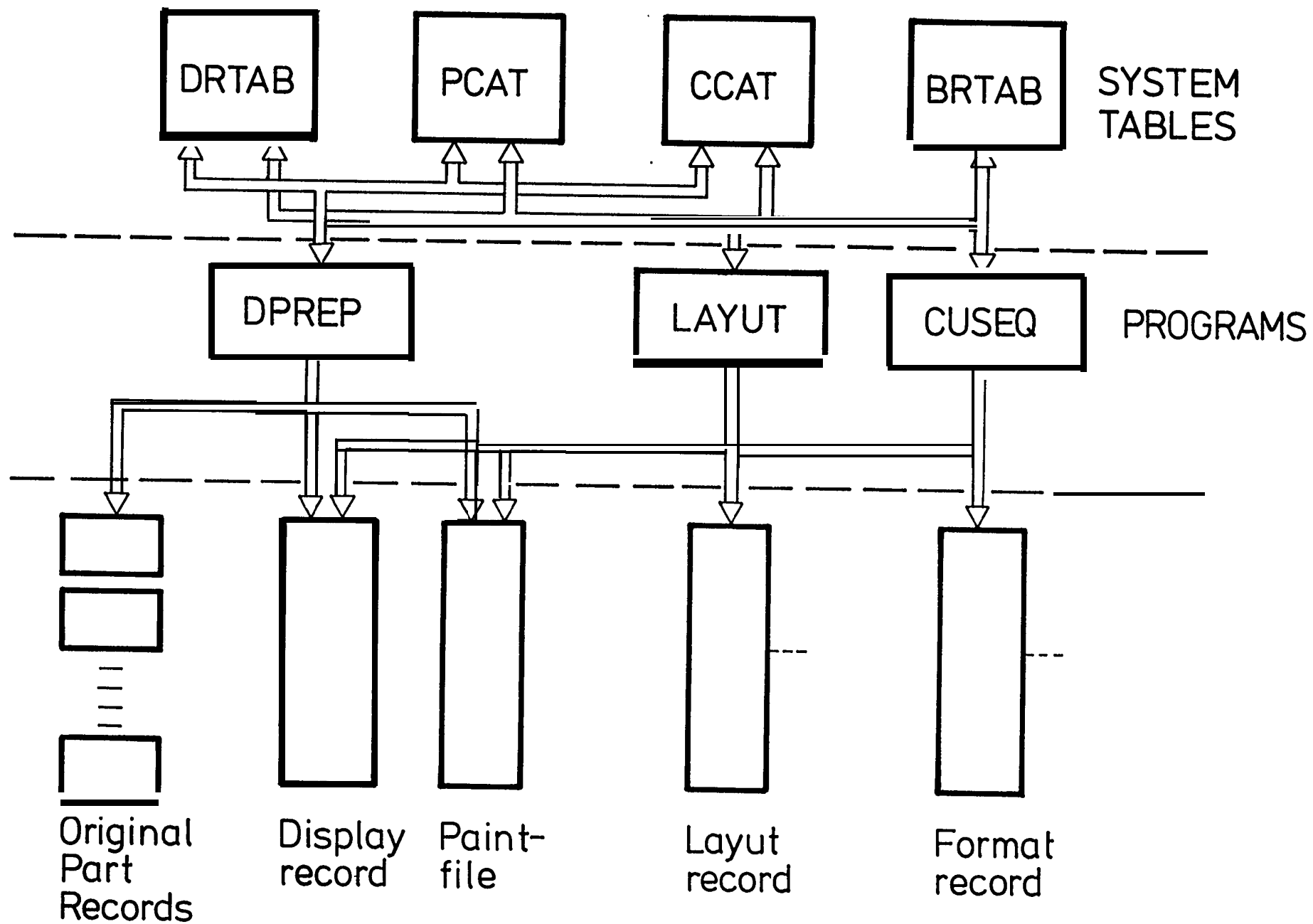


Figure 3

Before a part may be referenced in the LAYUT phase, it must be passed as qualified for nesting in the DPREP phase. This involves transferring the contour description to a system record, display record. A special table is maintained to control all these parts that have qualified for nesting. This system record associated table is our master reference data whenever a new copy of the part is needed, or when the nested format record is built as an end result of the nesting operation.

There is one more level in the data representation before a part becomes a picture for display. That level is the extracted desired contour parts of the master, with transformations and graphics processing applied. We call this level the paint file representation, since this is an exact copy of the data going to the display driver.

(This is done in order to redraw pictures quickly where minor changes have been introduced, or pictures previously shown, and to allow identification of the different contour elements).

Once the user has verified and prepared the desired parts, the layout of the parts may commence. The user must then change from DPREP to LAYUT phase, and while doing so the system does a lot of background work on the database - garbage collection, back-up, closing old and opening new communication links. Any change of phase has these effects on the database.

At any time, while in the LAYUT phase, the CUSEQ phase may be entered. The user may then input cutting sequence information about the parts already nested.

The complete sequential geometry description of a nested format is not built before the user requested NC information for the format. Until then all actions to do layout of the parts and specification of the cutting sequence result in parameters being stored in special system records. In this way the parameters are maintained throughout and changes are easily achieved.

Using the system

We have attempted to arrange the different commands available to the user into logical groups based on the type of action they perform.

Commands for entering parts to or dropping parts from the nesting system:

PARTS      -      in the DPREP phase the PART command prepares a part for nesting by entering the part in system contents table

                 in the LAYUT phase the PART command will display the part in menu area (see Fig. 4).

DROP        -      removes a parts entry in the system contents table. The command can also be used to remove records from the database.

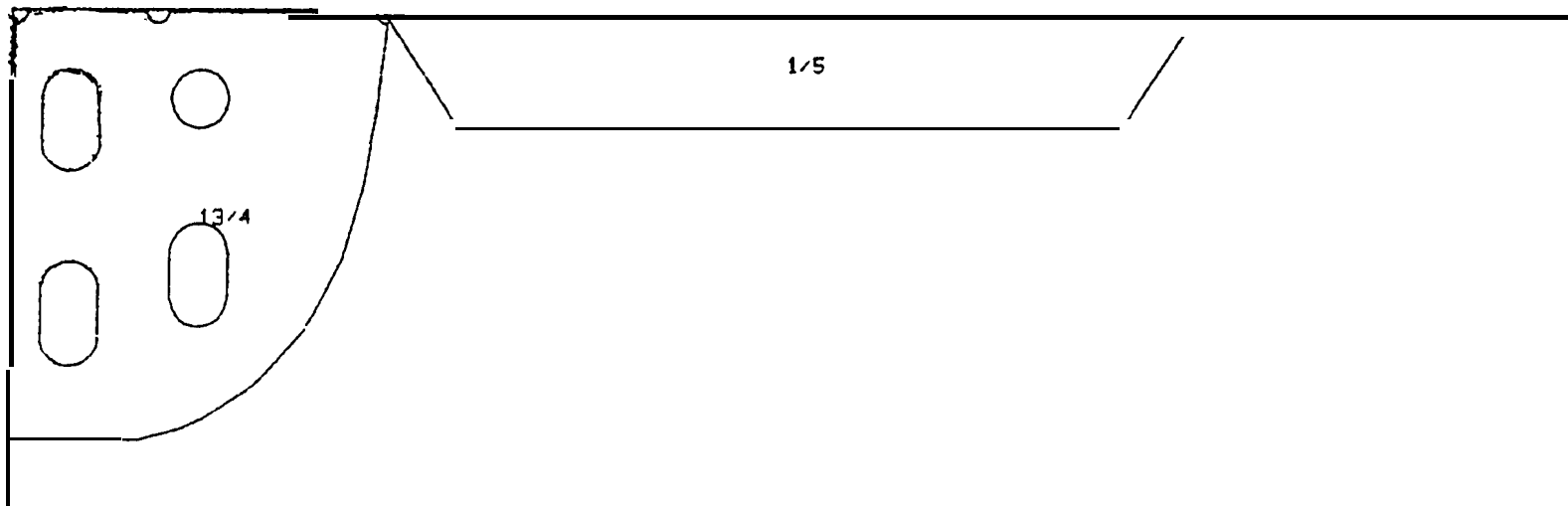
Commands for specifying formats and the layout of parts.

FORMAT     -      allows the user to specify a specific format size.  
                 The command is also used for:

                 recalling "old" formats  
                 changing a format  
                 shrinking a format around already  
                 nested parts  
                 removing formats

FRAME        To slide the format across the screen. Used to get the desired section of a large format on the screen.

MOVE        To translate a part from one position on the format or menu area to another position on the format. The movement is given by the crosshair cursor.



145

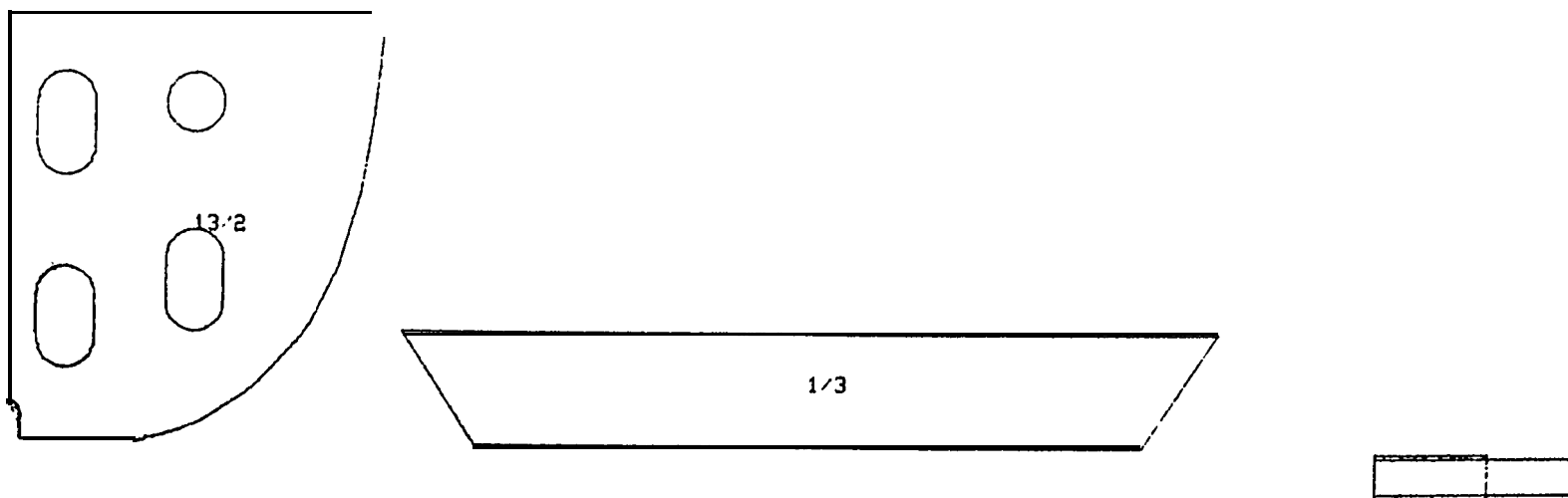


Figure 4

ROTATE	To rotate a part. The user identifies the point of rotation and the angle of rotation by crosshair input or by giving the angle in degrees.
MIRROR	To mirror a part. The user identifies the location of the mirror axis and in which plane the part is to be mirrored.
PLACE	Allows the user to specify a transformation (or a parts position) relative to the format edge or any other part such as placing two parts at a predefined distance for common cutting.
CHECK	To check for overlap between parts (not needed when parts are positioned by the PLACE command).
REMOVE	To remove or erase parts from a format.

Commands for displaying pictures and measurements:

SHOW	To display on the screen single parts details complete formats (squeezed to fit inside the screen area)
RESHOW	To reshow (or redisplay) pictures previously generated by the "show" command. Allows the user to reshow the last detail, single picture framed format. (The system keeps track of one level only, ie, last detail).
CLEAN	To clean up a messy picture. Redraws the framed format without old copies of parts that have been moved.

**DISPLAY** To display parts, prestored text, production information and tables. Display differs from the show command by allowing the user to page through the parts visualizing up to 4 parts at one time (see Fig. 5).

**DIMENSION** To take control measurements from displayed information. Works with the accuracy of the original part description (not limited by the screen accuracy).

Commands for specifying cutting sequence and other production information:

**ENTER** To specify a cutting tool path that is not included in a contour part description (bridge). Allows the user to specify one- or two-way bridges. The bridges may be horizontal or vertical or the direction may be given by cursor input.

**BRIDGE** To remove or change bridges on a format. The bridge is identified by pointing with the crosshair cursor.

**FOLLOW** To trace the cutting sequence of the whole format or any part of a sequence from a user specified point. An illuminated point is used to simulate the cutting tool.

**NEW** To specify a new cutting sequence. The total cutting sequence may consist of several uniquely identified sequences.

**POSITION** To position the cutting tool at a certain position. The position is given by cursor or coordinate input. No bridge is generated. (The command may be used in specifying where a bridge is to start).

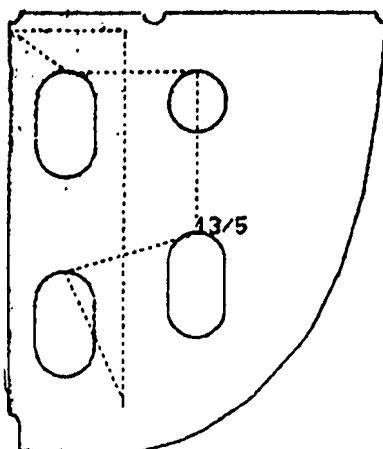
**RIBBON** To specify or change corner loops (given the name ribbon). The corner loops must be stored as contours and referenced by a user selected reference number.

T  
THICKN. AREA QUALITY MAT. NO.

1:30

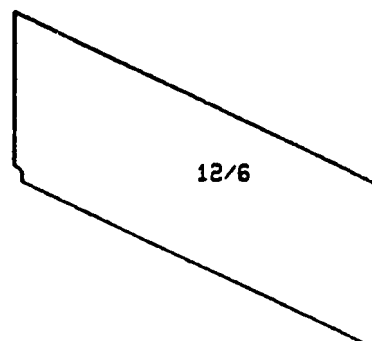
THICKN. AREA QUALITY MAT. NO.

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THICKN. AREA QUALITY MAT. NO.

1:30



THICKN. AREA QUALITY MAT. NO.

1:30

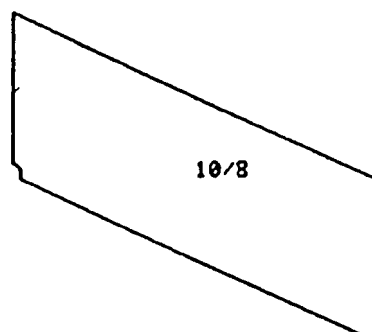
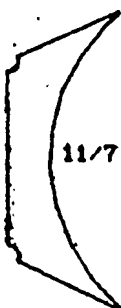


Figure 5

TOOL        To specify the cutting tool to be used. Includes facilities to turn torches on and off and to add/modify bevels on a part.

GENERATE To generate the following:

          one continuous contour of all the parts and the bridges  
          on the format

          on the basis of the continuous contour to generate a  
          tape for N/C or optical flamecutters.

          production information such as steel utilization, cutting  
          lengths, no. of preheats etc.

Commands for specifying system parameters:

CHANGE     To change the value of certain system parameters (such as  
          common cutting tolerance etc.).

SET        To set scalefactors and other parameters associated with the  
          display     on the screen.

SELECT     To select        contour elements of the part master (original part description) to be used. Used to display a certain contour type and to ensure identification of elements of proper type.

DEFINE     To define  
          texts associated with a picture on the screen

          new (user specified) contour types



#### System utility commands:

HELP        To give the user assistance in operating the system. Limited to listing available commands and how they are used.

DUMP        To dump system parameters and data areas.

TRACE       To set trace of certain system parameters during the execution of the following commands. (The Dump and Trace commands are mainly intended as a help for program development and debugging).

START       To start up the system initially or to start a new phase of the system. Any sequence of phase changes is allowed. Garbage collection and database backup taken.

SAVE        To save the system temporarily or permanently. The temporary saving of the system involves automatic regeneration of the last picture displayed if the system is restarted in the same phase.

#### Preliminary Conclusion

#### Status and experiences

At present the system is operative at CIIR and SRS where a pilot study is being performed in production environment. Based on the experience up to now we feel we safely can say that the Interactive Nesting System represents a definite improvement over the present nesting system. Our experienced "nester" estimates the average time spent on generating a nested format is reduced from 2-3 hours to 15-45 minutes, not including the delay caused by running to-day's batch jobs and getting the final formats drawn for control purposes.

The task is a demanding one with respect to computer power at the level of accuracy we find necessary. A minicomputer in the upper range of the performance spectrum, (floating point hardware, 64K) is recommended, especially if the system is supposed to be used in a multi-user environment.

The Tektronix 4014 Storage Display seems to be fairly well suited for this type of operation, even if, to a certain extent, it is a dynamic one. The pictures produced on the Tektronix display have the high quality required. However, such systems should be designed with the limitations of storage displays in mind, and a high transmission speed from/to the display is required.

#### Future development

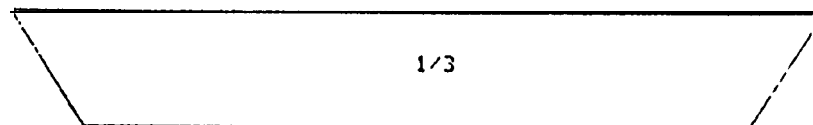
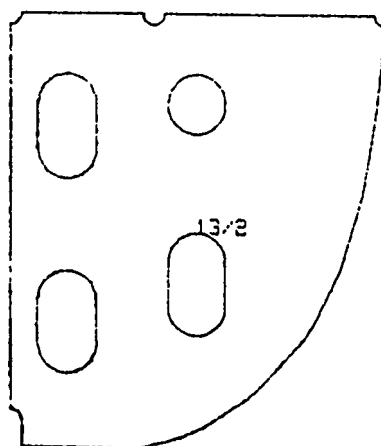
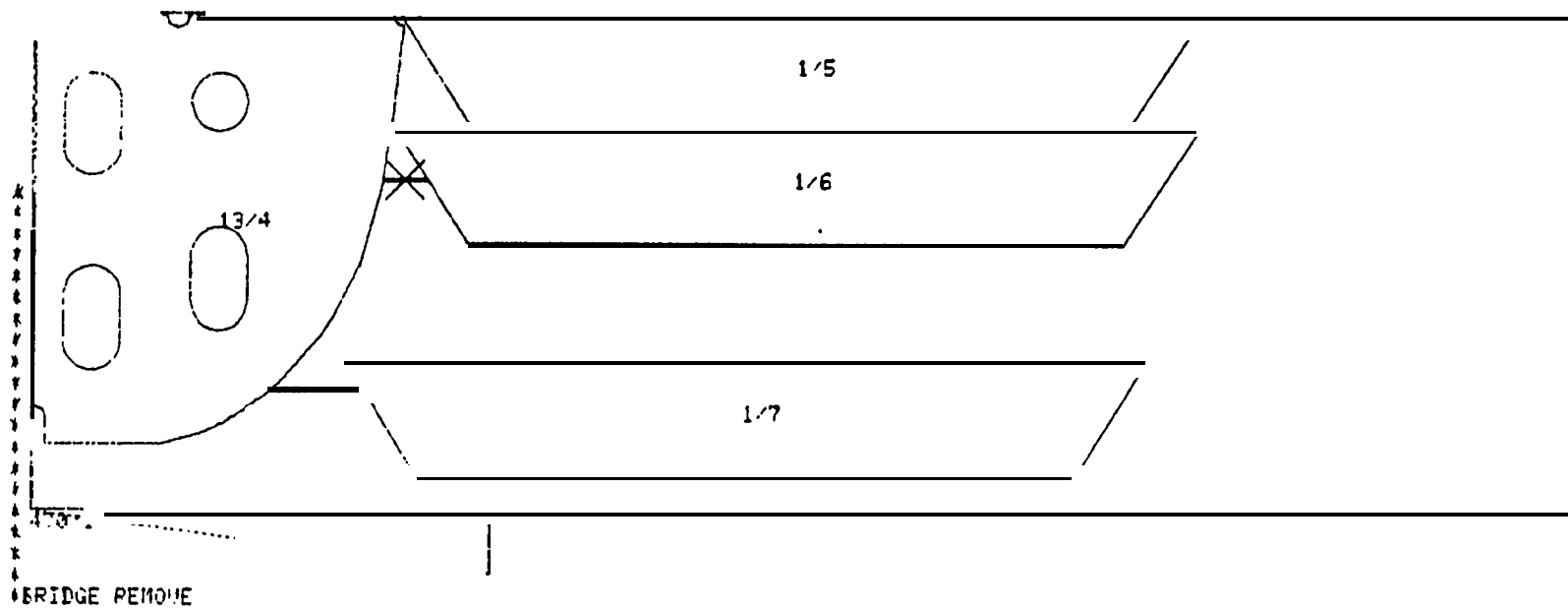
The system design and the programs will be used as the basis for future development in the AUTOKON-line.

At the moment the following two projects have been started:

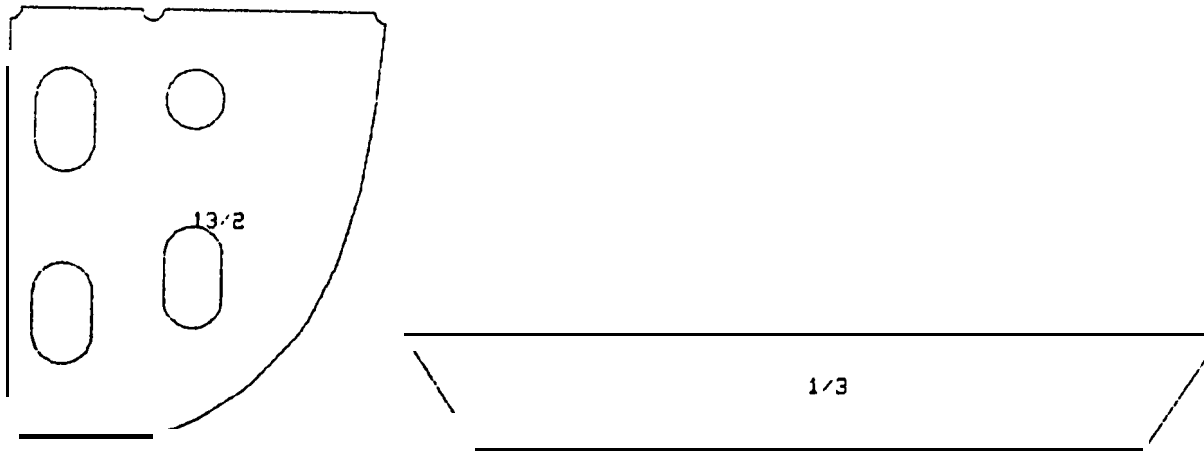
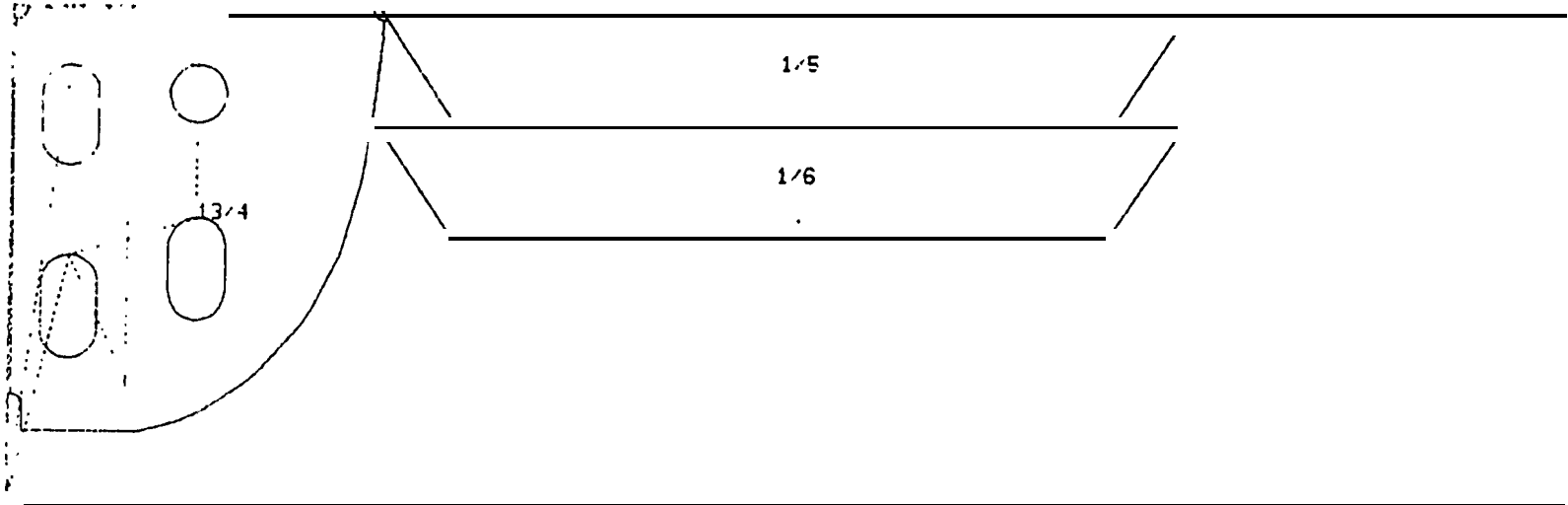
- Interactive part splitting/coding

- A system for generation of drawings.

# EXAMPLE OF CUTTING SEQUENCE SPECIFICATION

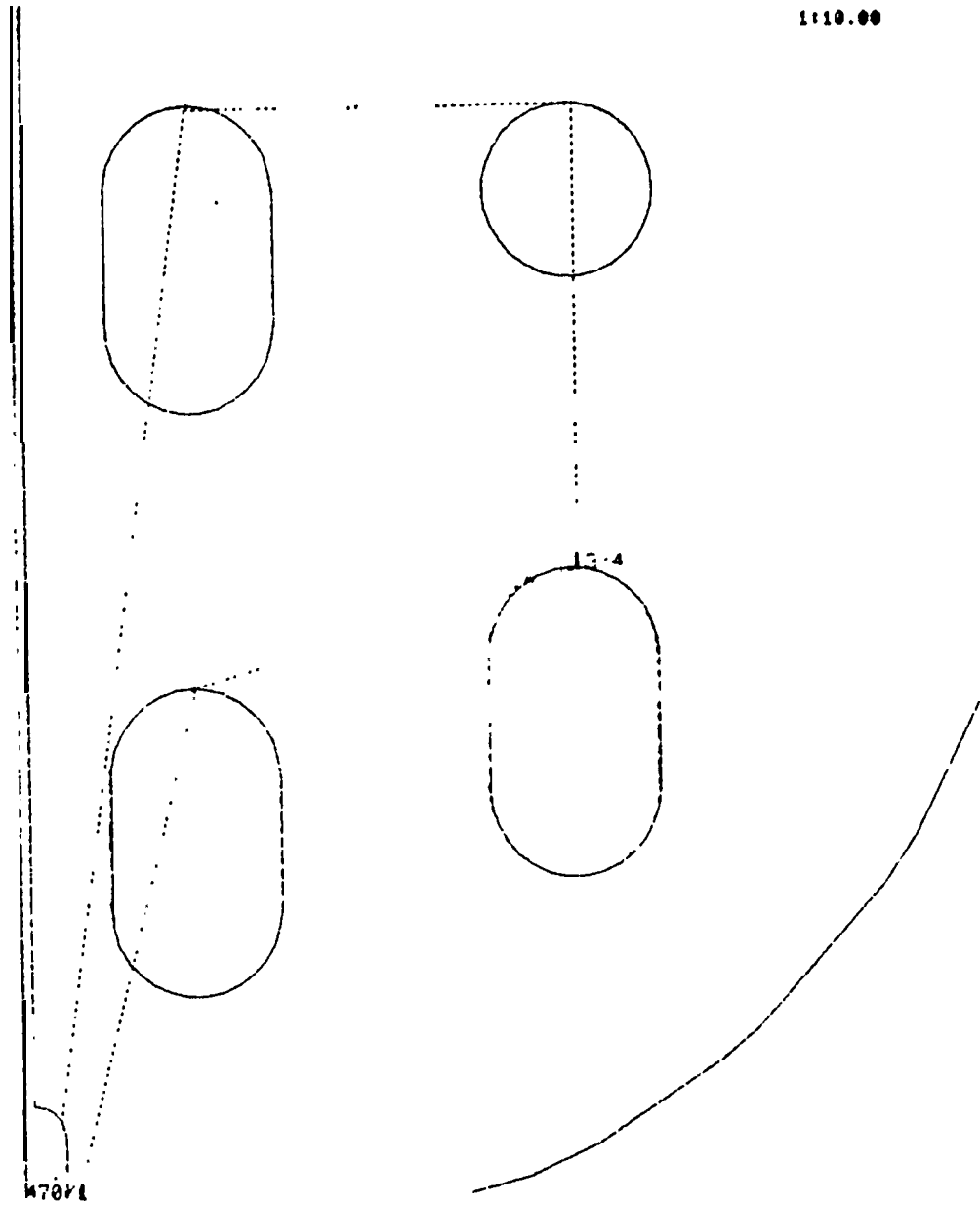


# EXAMPLE OF CUTTING SEQUENCE SPECIFICATION



# EXAMPLE OF CUTTING SEQUENCE SPECIFICATION

1:10.00



## References

1. All documentation of the AUTOKON system related to nesting. By courtesy of Shipping Research Services Ltd., Oslo, Norway.
2. Eng, O. "An investigation on interactive autokon modules". SRS (1971) .
3. Adamowicz, M. "The optimum two-dimensional allocation of irregular, multiply-connected shapes with linear, logical and geometric constraints". New York University (1970).
4. Lillehagen, F.M. and Riesenfeld, R.F. "An interactive computer graphics approach to the problem of nesting of plane parts on a raw steel format". University of Utah (1973).
5. Wade, J. and Wiwat, W. "COMPUNEST - computerized material utilization systems". Precision Patterns Inc., New Jersey, USA (1973).
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11. Lillehagen, F. "Interactive computer graphics in shipbuilding". AUC-meeting, Norway (1974).

## THE ADAGE NESTING AND DRAWING SYSTEM

Ned O. Shattuck

Adage Inc.

Boston, Massachusetts

Mr. Shattuck is currently the International Marketing Manager at Adage Inc. Before joining Adage, he worked for the Univac European Division, and as a unit chief and supervisor of N/C and M/D computing for the Boeing Company.

## 1. INTRODUCTION

The ADAGE Interactive Nesting and Drawing System is based on the ADAGE GS/300 Interactive Graphics System and a main host computer. The main computer contains the ship design routines, such as AUTOKON, and the Graphics Display System is used to display individual parts calculated by AUTOKON or to draw new parts as may be required, to visually nest these parts on a sheet metal plate, then to display the tool path required to cut the nested parts layout.

This Nesting and Drawing package was first developed two years ago as a feasibility study by ADAGE, s. p. a. in Italy for a major Italian shipyard, Italcantieri, s. p. a. Since that time Italcantieri has completed the development to the point that it is scheduled to go into production in July, 1976.

The Italcantieri equipment configuration is an:

- ADAGE GS/340 with
- 32-K of 30-bits/word core memory
- 2- 81- million bit disk drives
- 1- electrostatic printer plotter
- 2- 23" round CRT display consoles,

each with:

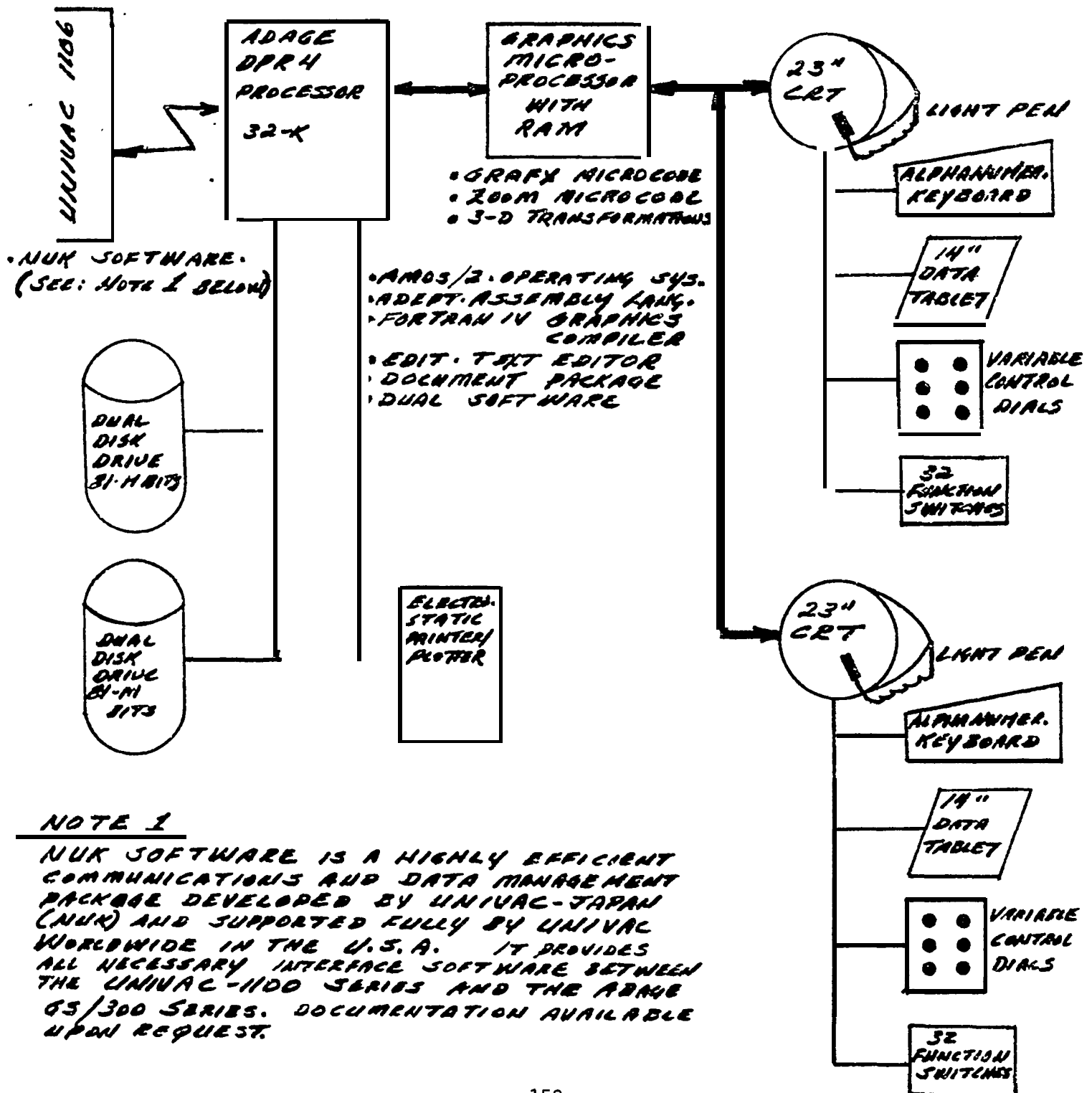
- Alphanumeric Keyboard
- 32 Function switches
- 11" Data Tablet
- Variable Control Dials (6)
- Light Pen (not used)
- Hardware Window
- Circle Generator
- Dynamic Zoom (128:1)

All running remote (3 km. ) to all UNIVAC 1106 multiprocessor via a 50-K baud line. (See Figure A)

The software as described herein and in the Software Specification is available from ADAGEI or Italcantieri,



# SYSTEM CONFIGURATION ADAGE GS/340 DUAL CONSOLE AT ITALCANTIERI



## NOTE 1

NUK SOFTWARE IS A HIGHLY EFFICIENT COMMUNICATIONS AND DATA MANAGEMENT PACKAGE DEVELOPED BY UNIVAC-JAPAN (NUJ) AND SUPPORTED FULLY BY UNIVAC WORLDWIDE IN THE U.S.A. IT PROVIDES ALL NECESSARY INTERFACE SOFTWARE BETWEEN THE UNIVAC-1100 SERIES AND THE ADAGE GS/300 SERIES. DOCUMENTATION AVAILABLE UPON REQUEST.

**FIGURE - A**

## II. DRAWING MODE

This mode allows the operator to draw new parts to be stored or nested. The operator has at his disposal

- A Display Screen (CRT)
- Digital Data Tablet
- Variable Control Dials
- 32 Lighted Function Switches
- 2 Foot Pedals

He also has a constantly up-dated list of geometric parameters displayed on the bottom of the screen. These are, as they appear:

DELTA X	X
DELTA Y	Y
REL. ANG.	ABS. ANG.
DISTANCE	DETAIL
	GRID STEP

Where

DELTA X	Increment, along the X-axis, of the current vector with respect to the end point of the previous vector.
DELTA Y	Increment, along the Y-axis, of the current vector with respect to the end point of the previous vector.
REL. ANG.	Angle included between the current vector and the previous one.
DISTANCE	Length of current vector.
X	Distance along X-axis of the moving end of current vector with respect to the specified origin.
Y	Distance along Y-axis of the moving end of the current vector with respect to the specified origin.
ABS. ANG.	Angle included between the current vector and the X-axis (unrotated)
DETAIL	Maximum precision used.
GRID STEP	Step value of the reference grid when it is displayed.

The range of values of the coordinates displayed on the screen are a direct function of the steel sheet to be worked. At the present time it is possible to specify a steel sheet with dimensions of 16.350 meters x 16.350 meters (53. 1 ft. x 53.1 ft. ) and keep an overall precision of 1.0 mm. (0. 039 in. ) Larger sheets can be dealt with, but at a loss of precision. For example, sheets with dimensions between 16.350 meters (53. 1 ft. ) and 32.7 meters (106. 2 ft. ) can be handled but with a precision of only 2 mm. (0. 078 in. ) which is about 5/64 of an inch.

The above values change in meaning as the user changes operations. For example, by placing the stylus in contact with the data tablet a cross is displayed on the screen. The cross moves correspondingly with the stylus until the cross is in the desired position. By depressing the tip-switch a point is selected. If the stylus is then moved to a new point, the values in DELTAX and DELTAY contain the incremental values of X and Y from the previous point and the values in X and Y contain absolute values of X and Y with reference to a specified origin, such as the lower left-hand corner of the steel plate. DELTAX and DELTAY can also be used as the center of a circle while the DiSTANCE value can be used as the radius. At times, it may be difficult to position the stylus and obtain an exact desired numerical value displayed on the screen. In this case the operator can press a function switch (9 - 12) to select the fine tuning function which allows him to scale the movement of the stylus so that one inch of movement of the stylus will produce 0. 1 inch of movement on the screen. The scale values selectable range from 5 to 1000. Therefore, any particular numerical value within range can be exactly obtained.

The attached Software Specification describes the geometric entities available and a Software Operating Instruction Manual is available from ADAGE.

### III. NESTING MODE

A list of parts to be nested can be called from storage on the main computer and stored on ADAGE disk storage. This can be done periodically so that many parts are called at once - the ADAGE GS/300 then runs stand-alone until a completed cutter path or group of them are ready to be transmitted back to the main computer for storage or processing. Individual parts may now be called up on the screen. These can be parts previously drawn using the CRT or those created directly by the AUTOKON package. These parts are then automatically scaled to correspond to the scale of the sheet of metal being displayed. Each part, or a group of parts, can then be translated in X and Y using variable control dials A and B and rotated around the Z-axis by turning variable control dial C. They can be rotated around the center of gravity or any selected point. There are various functional operators in the system to make the operators task easier, for example, selecting one edge of the plate and a straight line edge of a part will cause that part to position along the edge of the plate. Or parts with two straight edges may positioned adjacent and parallel, offset by the cutting torch diameter (A variable system parameter). Throughout the Nesting operation a value is displayed which indicates the percent of the sheet metal being used.

In the Nesting mode up to eight sheets of metal of different sizes and differently oriented may be stacked up, so that the parts being nested at that time will appear on all sheets displayed at that time.

The full capabilities of the Nesting Mode, including:

- **Part storage and retrieval**
- **Parts set-up**
- **Nesting completion, and**
- **Nesting storage and retrieval**

are discussed in detail in the attached Nesting Software Product Specification.

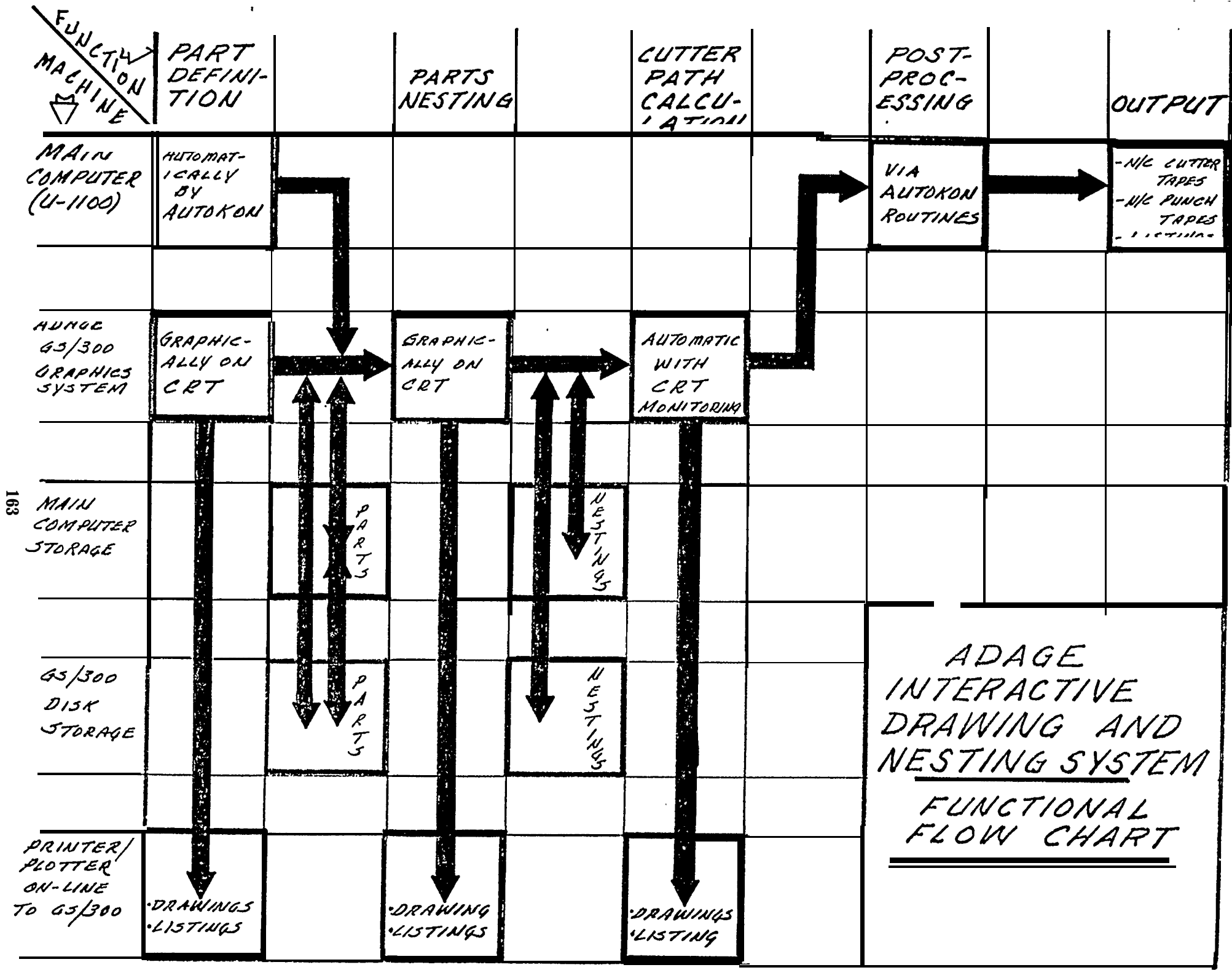
#### IV. CUTTER PATH CALCULATION MODE

Once a Nesting is completed, or hopefully completed, the operator can use the stylus to indicate where he wants any connecting bridges to be left. He then indicates the beginning cut point and direction of cut. The system then calculates the cutter path for all parts in the Nesting, leaving bridges of a previously defined width where ever indicated. At the bottom of the screen are shown three values

- Length of path in cutting mode,
- Length of path in positioning mode,
- Ž Total machine tool time.

The Nesting may then be rearranged or the cutting order re-directed in order to give the optimum use of material and machine time.

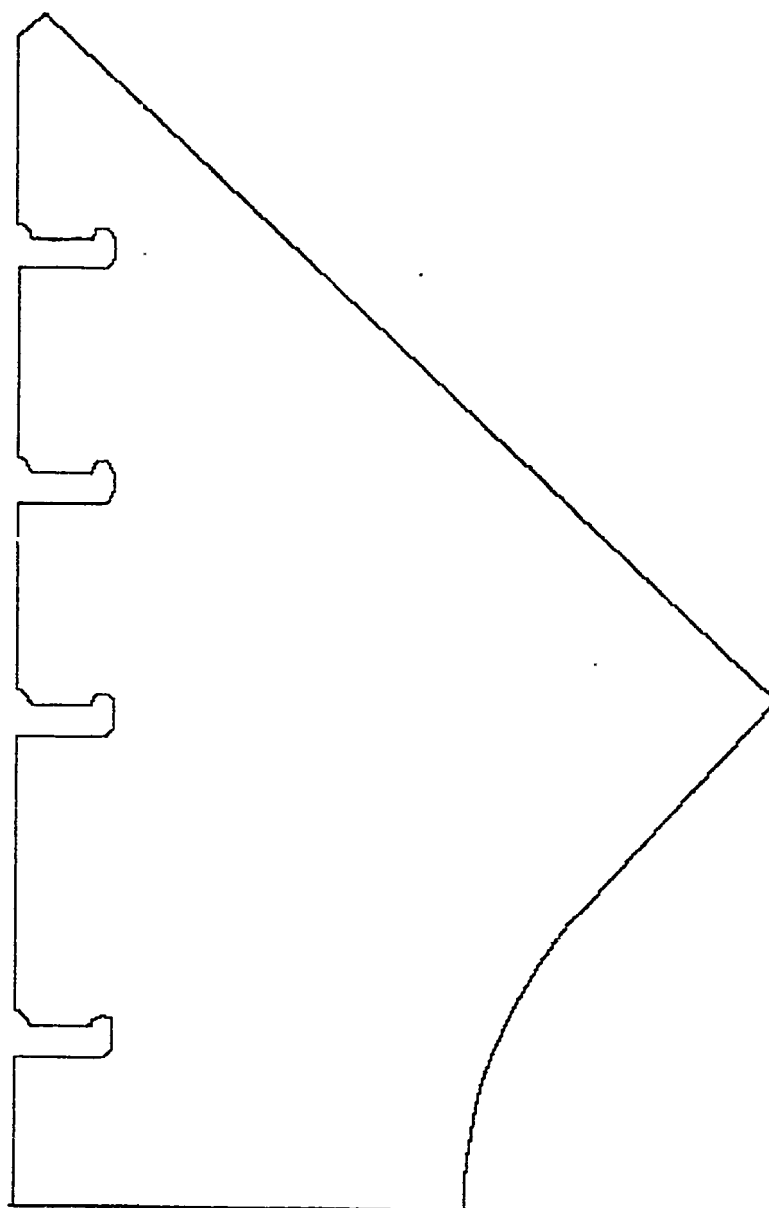
Once the cutter center path for the completed nesting is calculated, displayed, and accepted, it is then passed back to the host computer for postprocessing by AUTOKON to produce numerical control tapes to machine the parts.



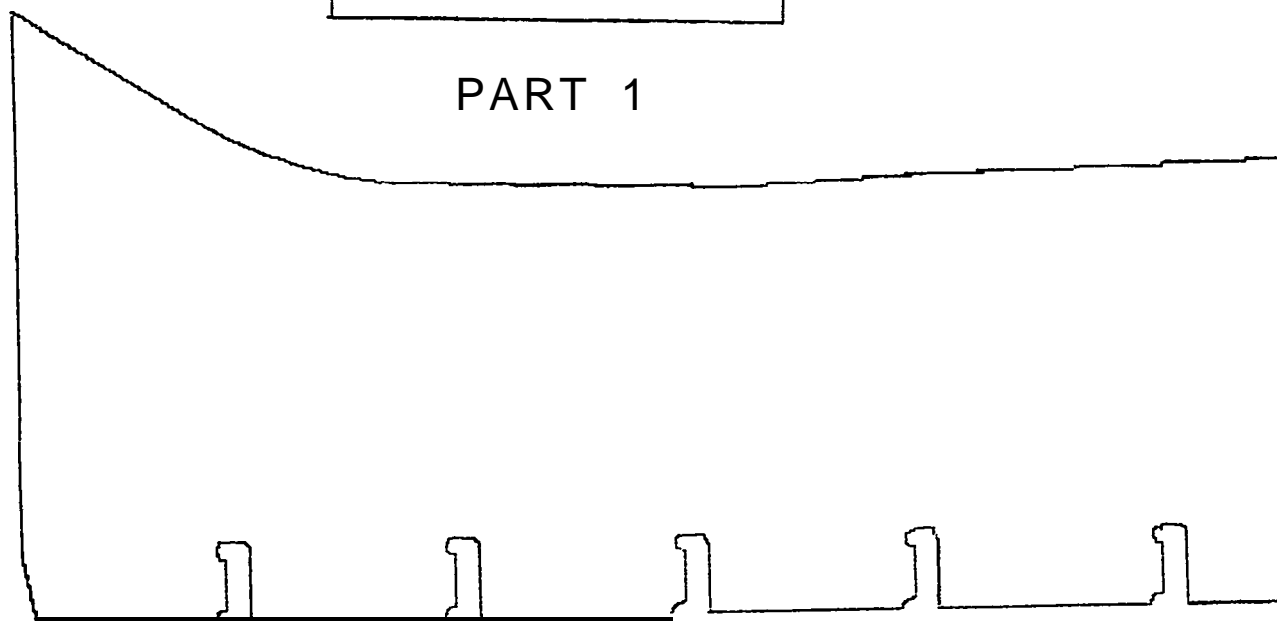
## NESTING EXAMPLE (PRINTER - PLOTTER OUTPUT)

Figures 1 - 5	Previously defined parts (PART 1- PART 5)
Figures 6 - 7	PART 1 and PART 3 called (in random position) onto sheet metal outline
Figure 8	PART 3 repeated and reflected
Figure 9 - 11	PART 2, PART 4, PART 5 called
Figure 12 - 13	PART 3 positioned
Figure 14	PART 2 and PART 5 - rough position
Figure 15	PART 1 - rough position
Figure 16	PART 5 - positioned, PART 4- rough positioned
Figure 17	PART 2 and PART 4 positioned
Figure 18	Bridge Defined
Figure 19	Cutter Path Beginning (Zoomed)
Figure 20 - 22	Cutter Path Continued
Figure 23	Cutter Path Completed

**Figure - 1**



**PART 1**



**Figure - 2**

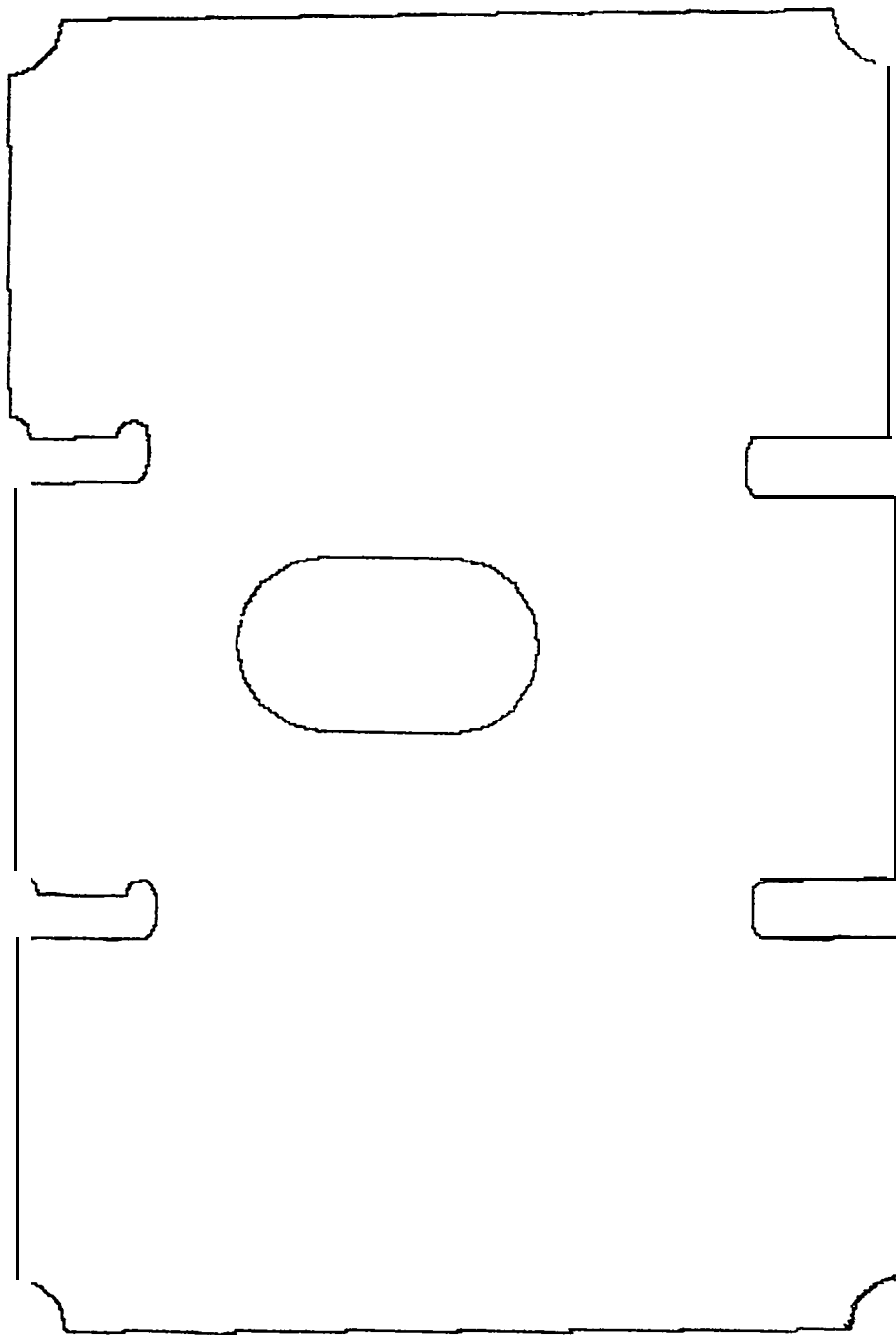
**PART 2**



Figure - 3

PART3





PART4

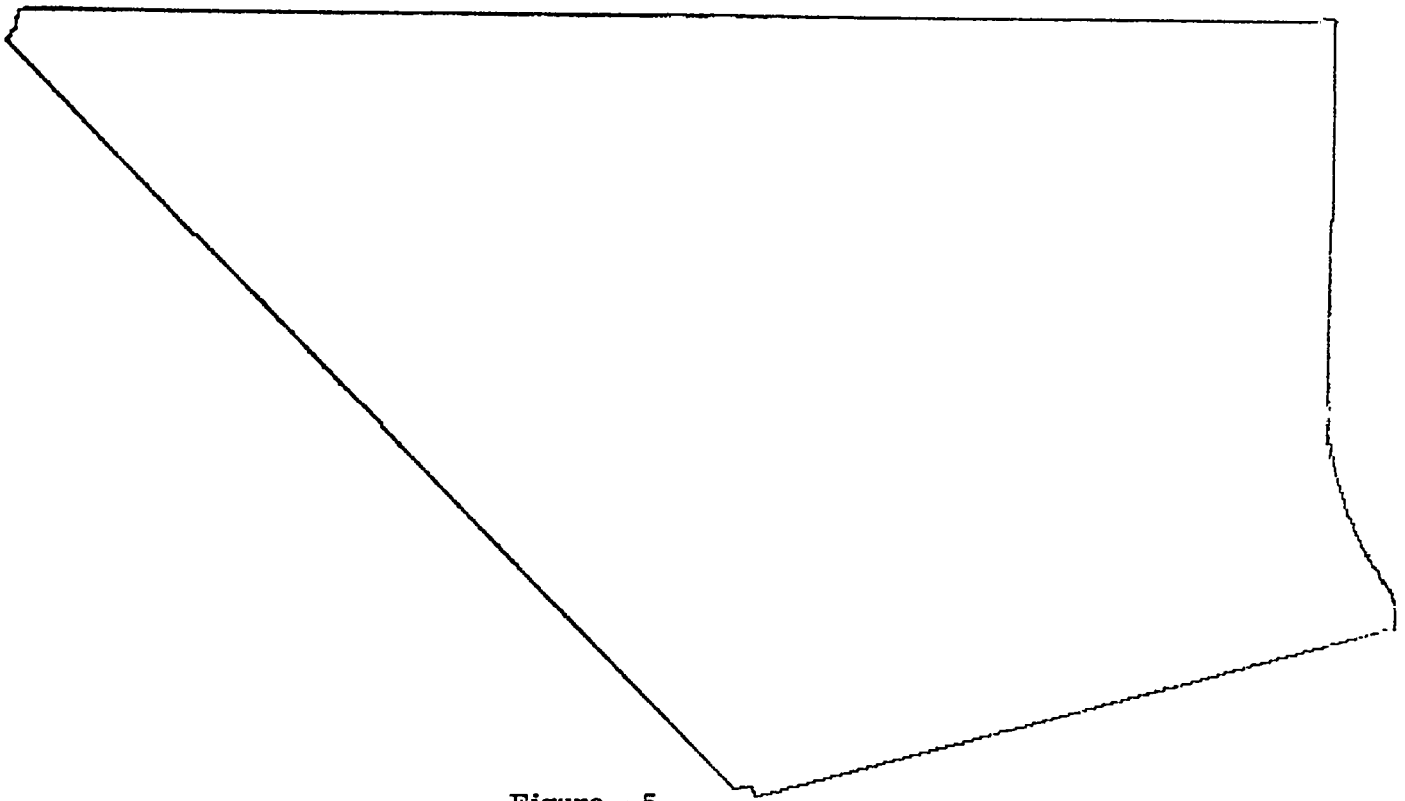


Figure - 5

PART5

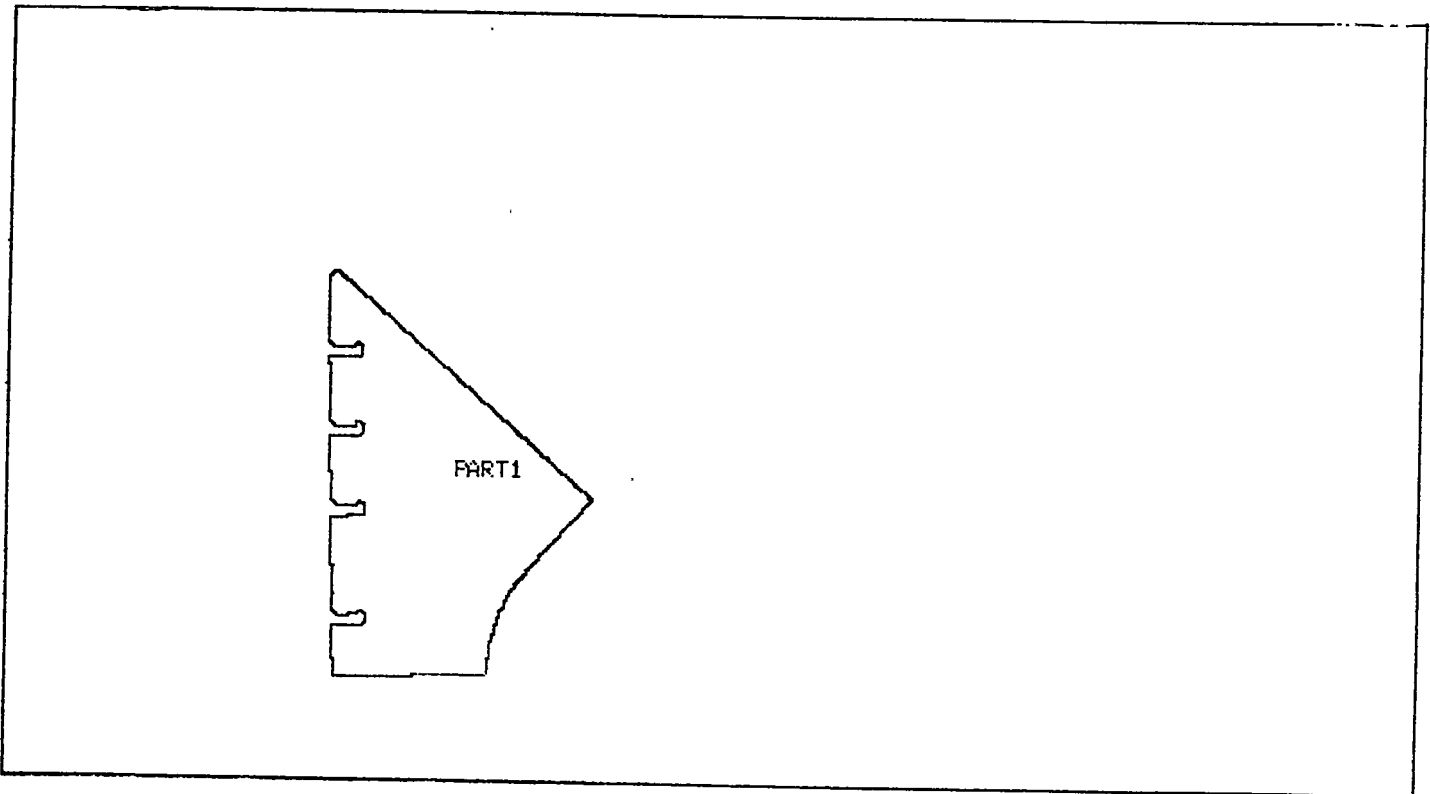


Figure - 6

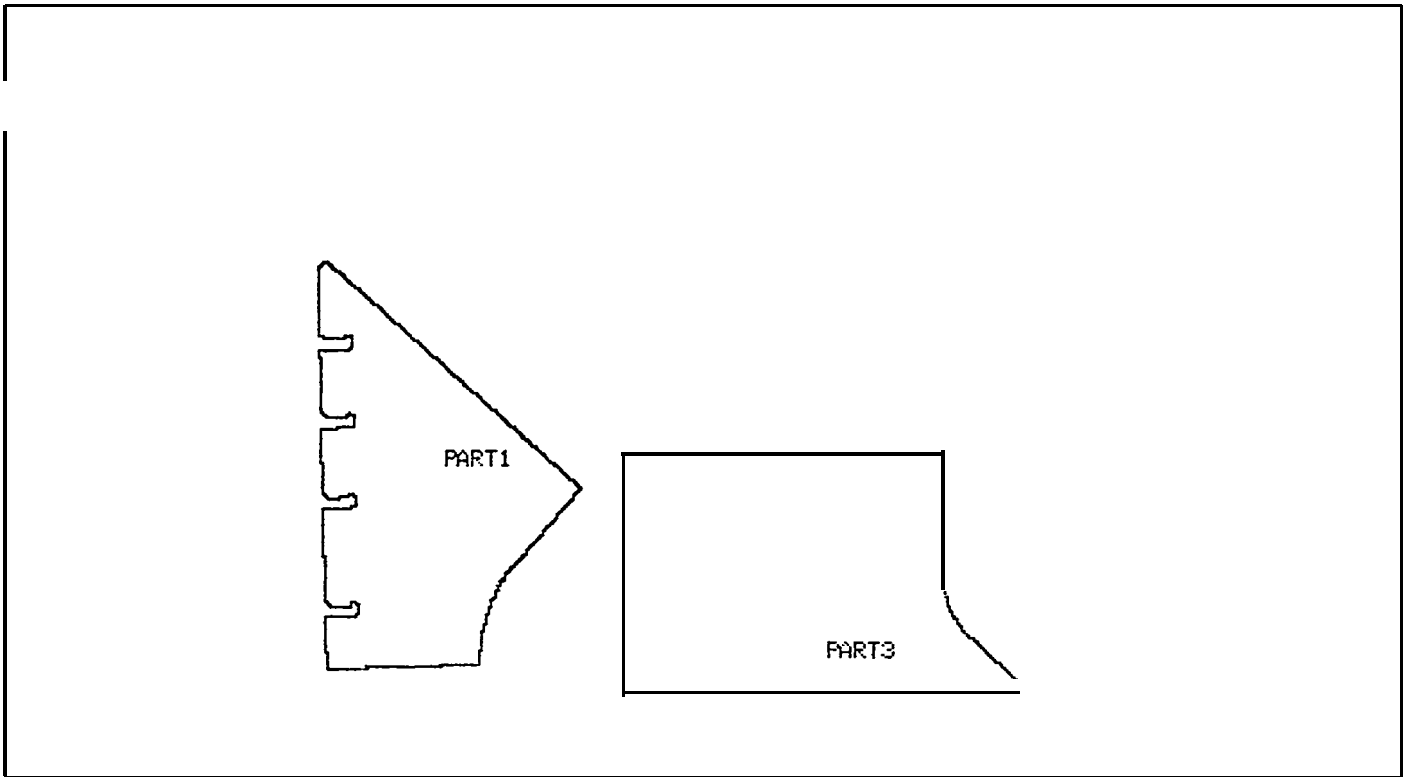


Figure - 7

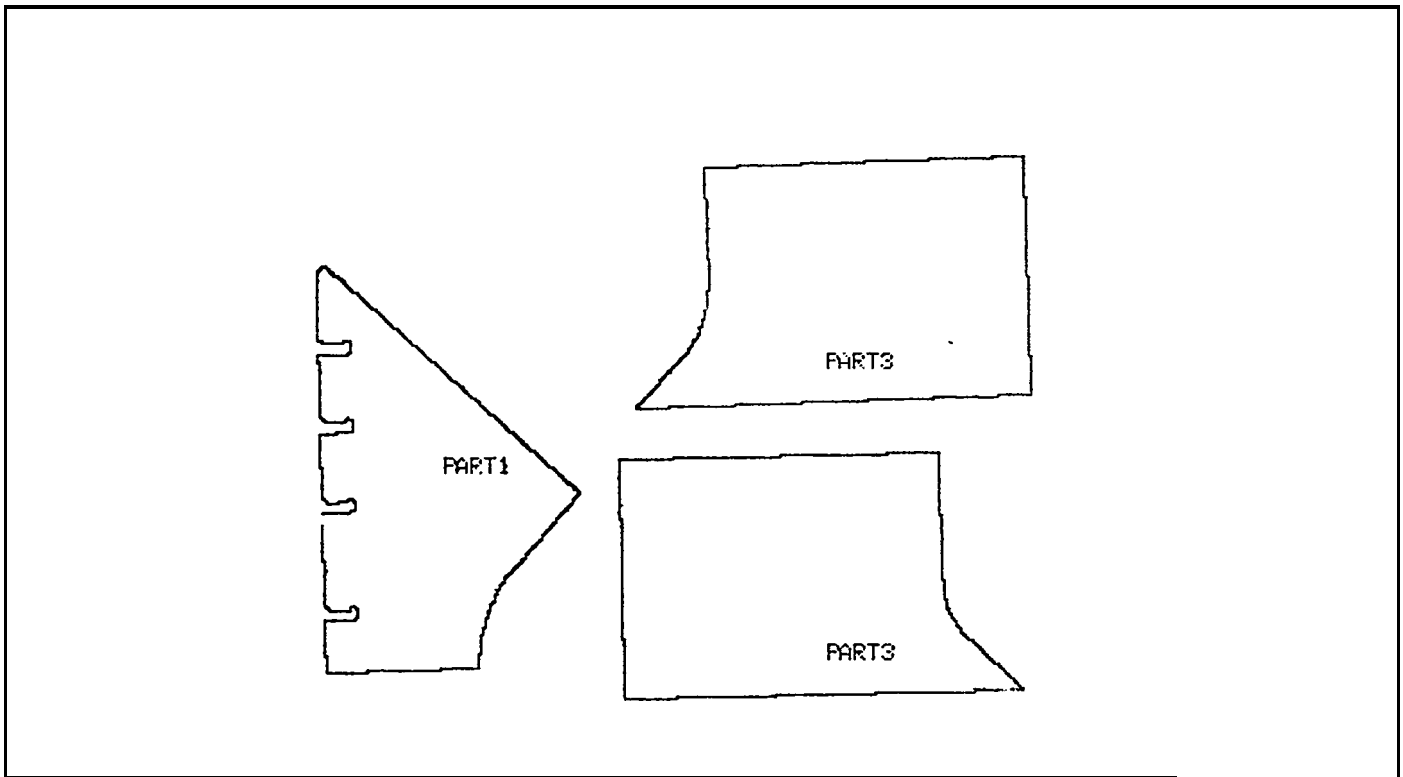
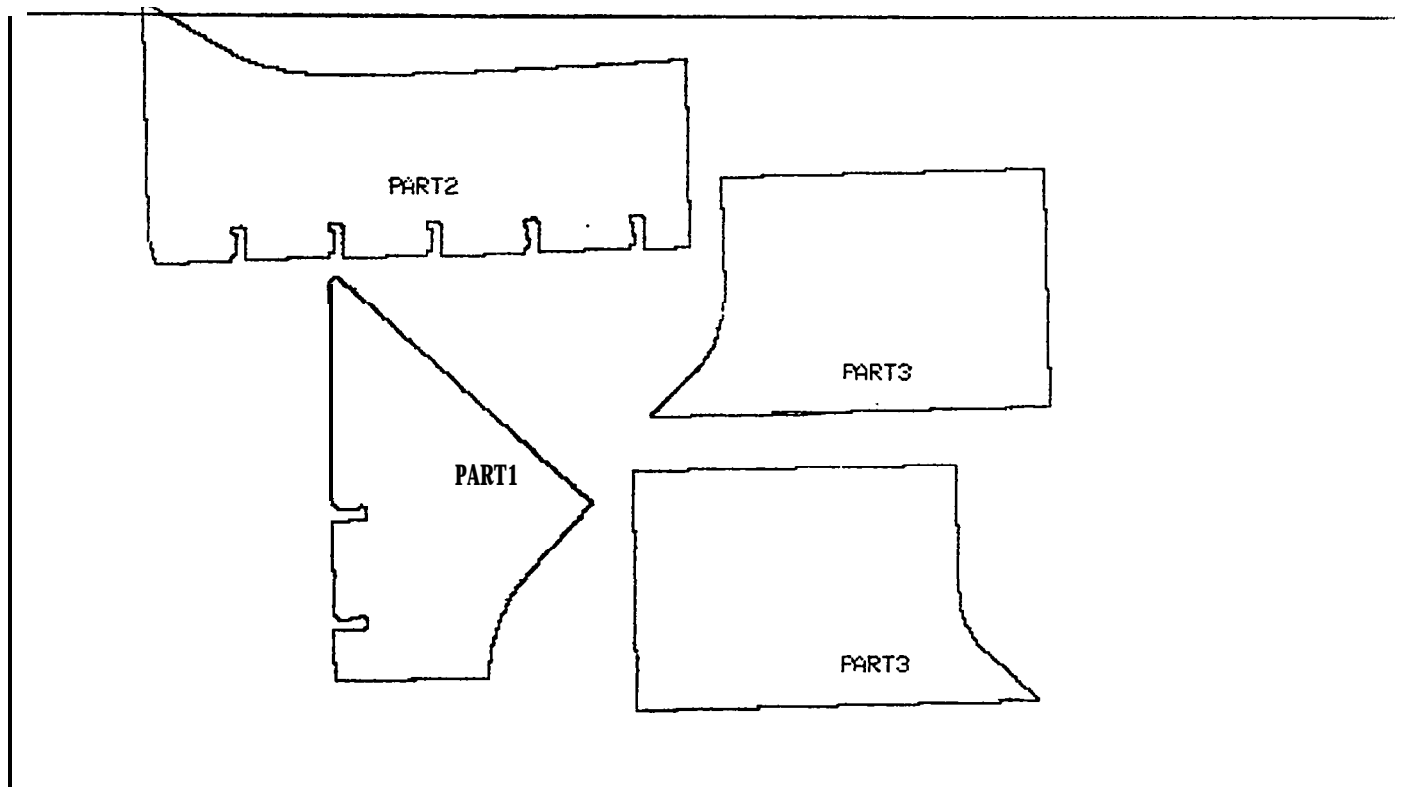
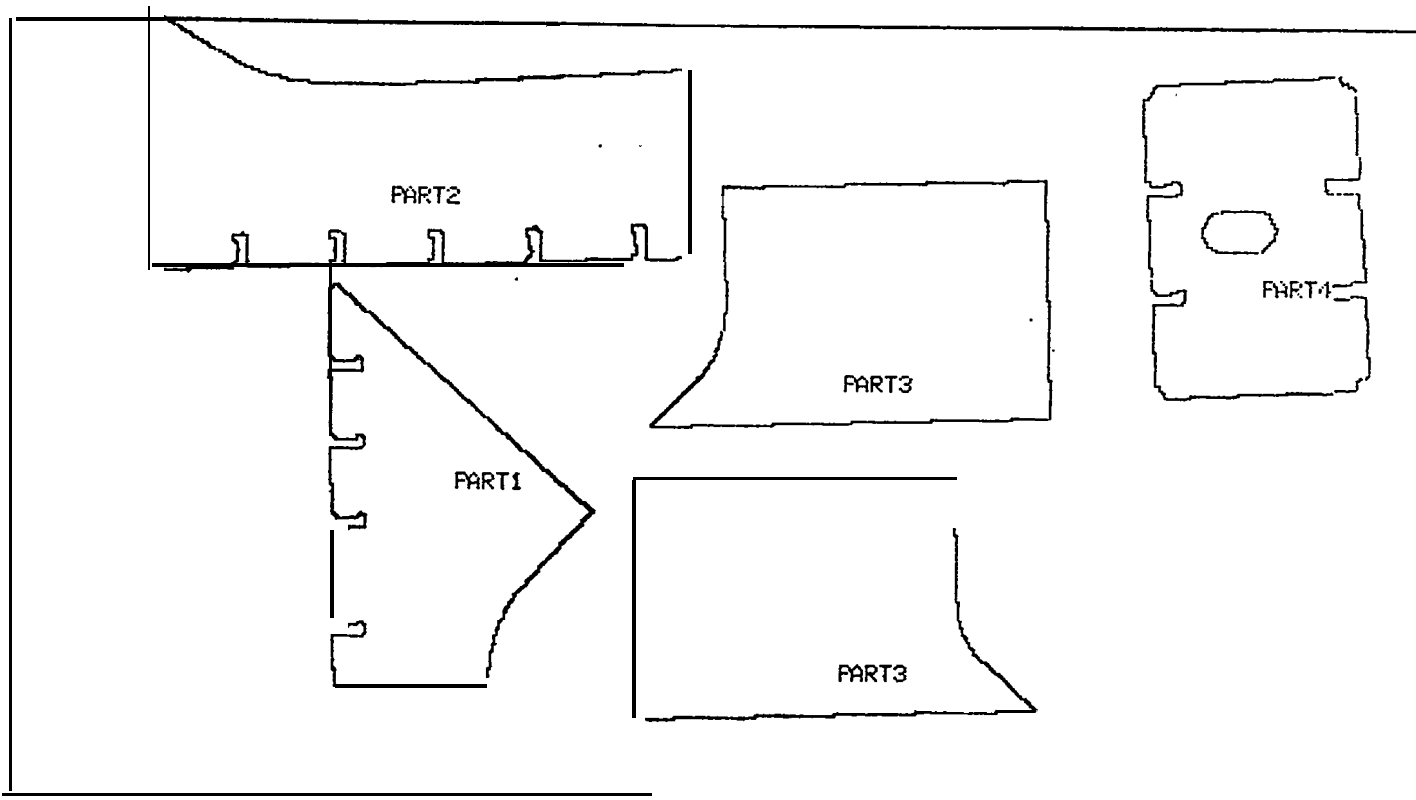


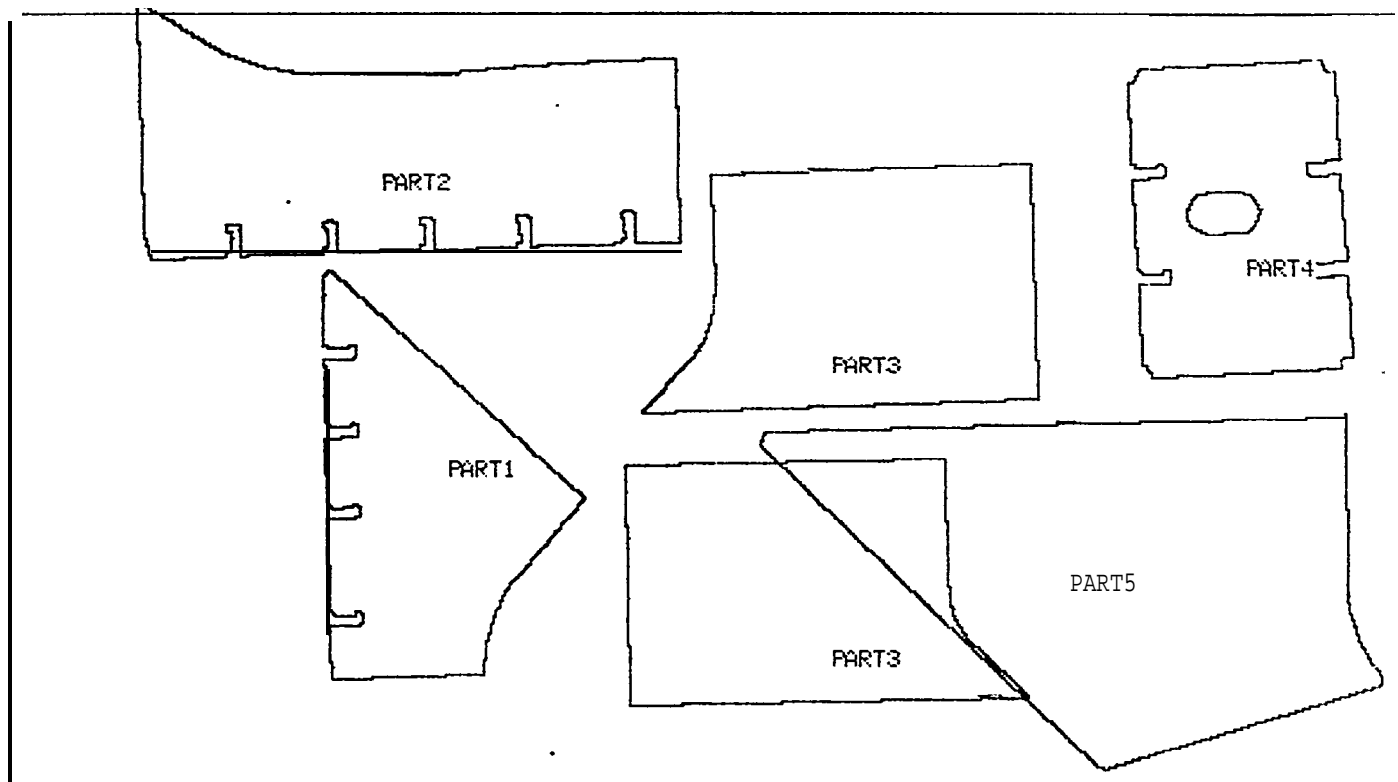
Figure - 8



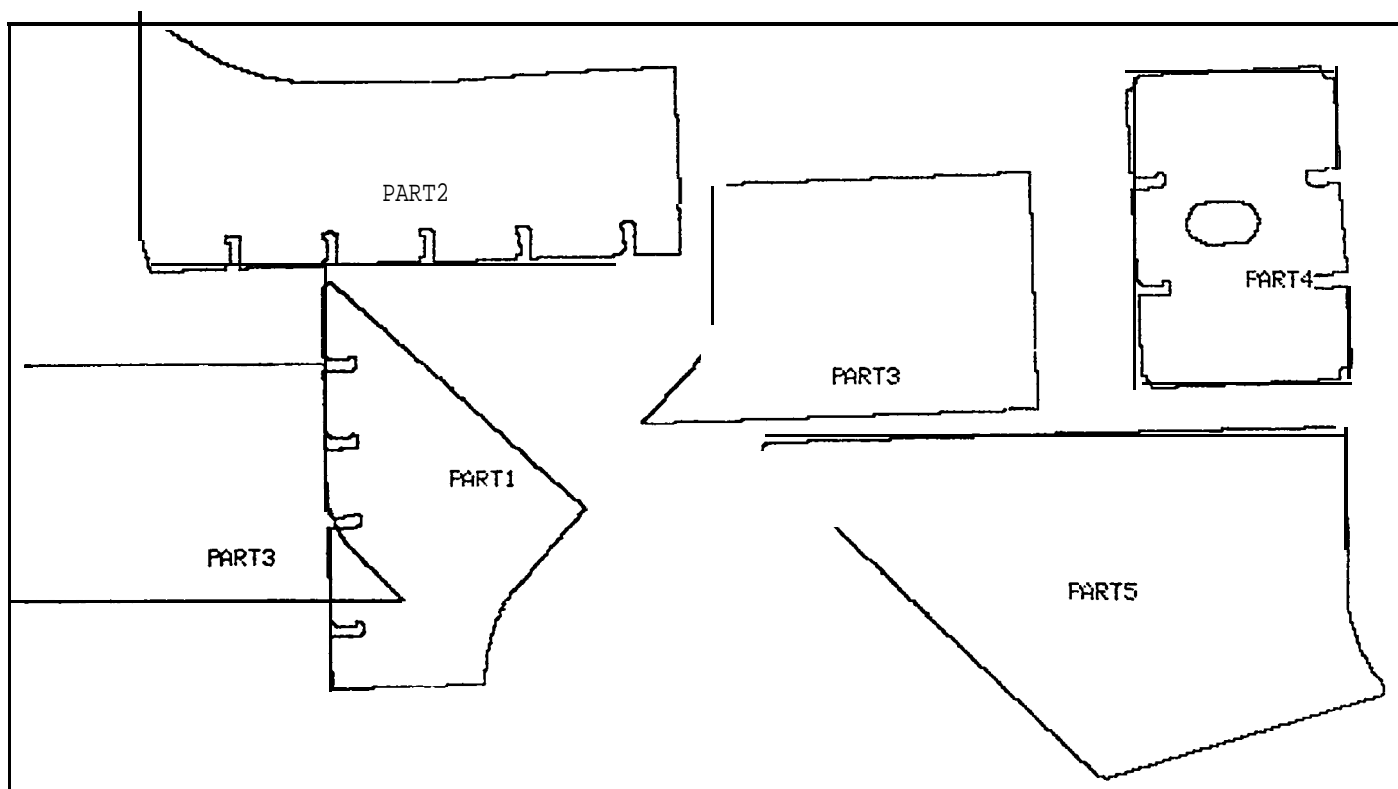
**Figure - 9**



**Figure - 10**



**Figure - 11**



**Figure - 12**

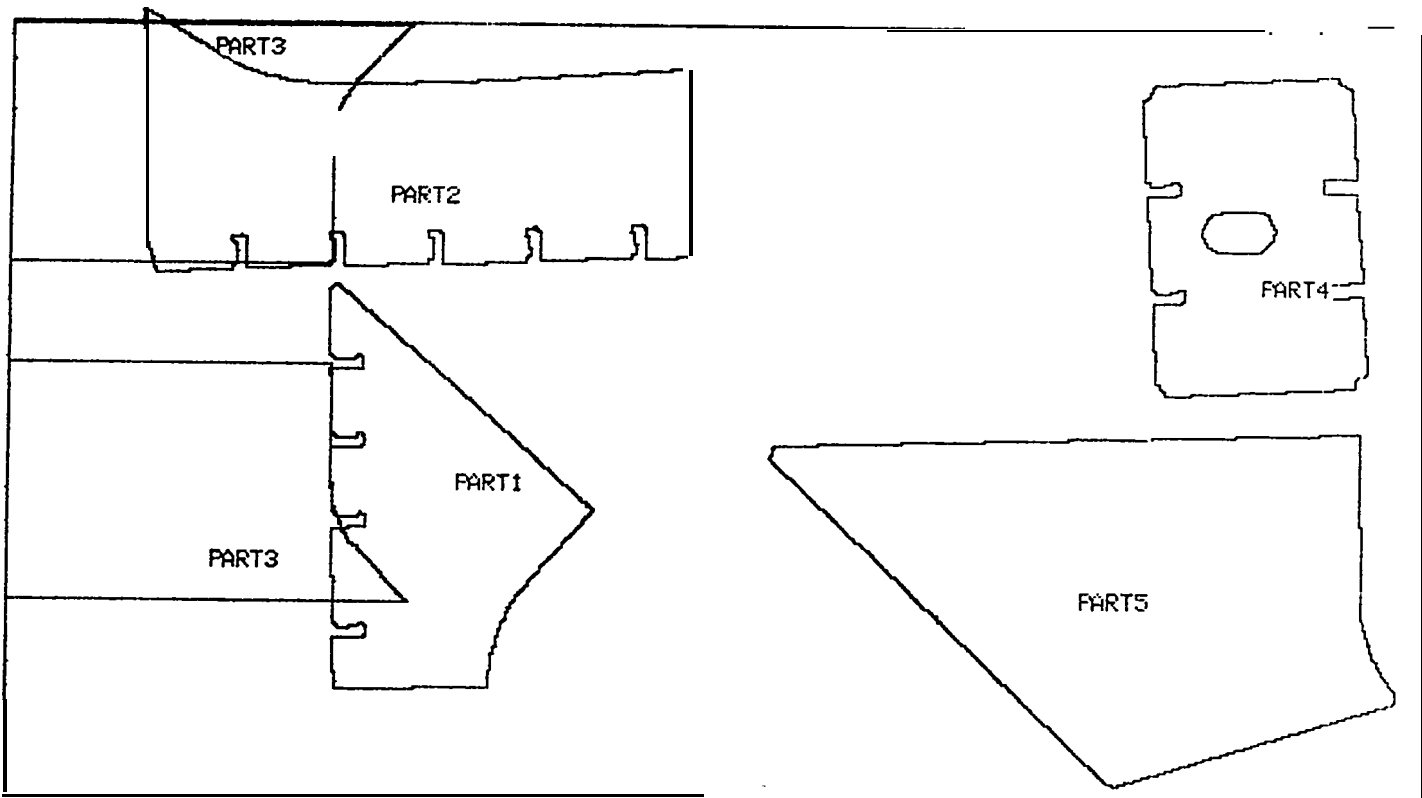


Figure - 13

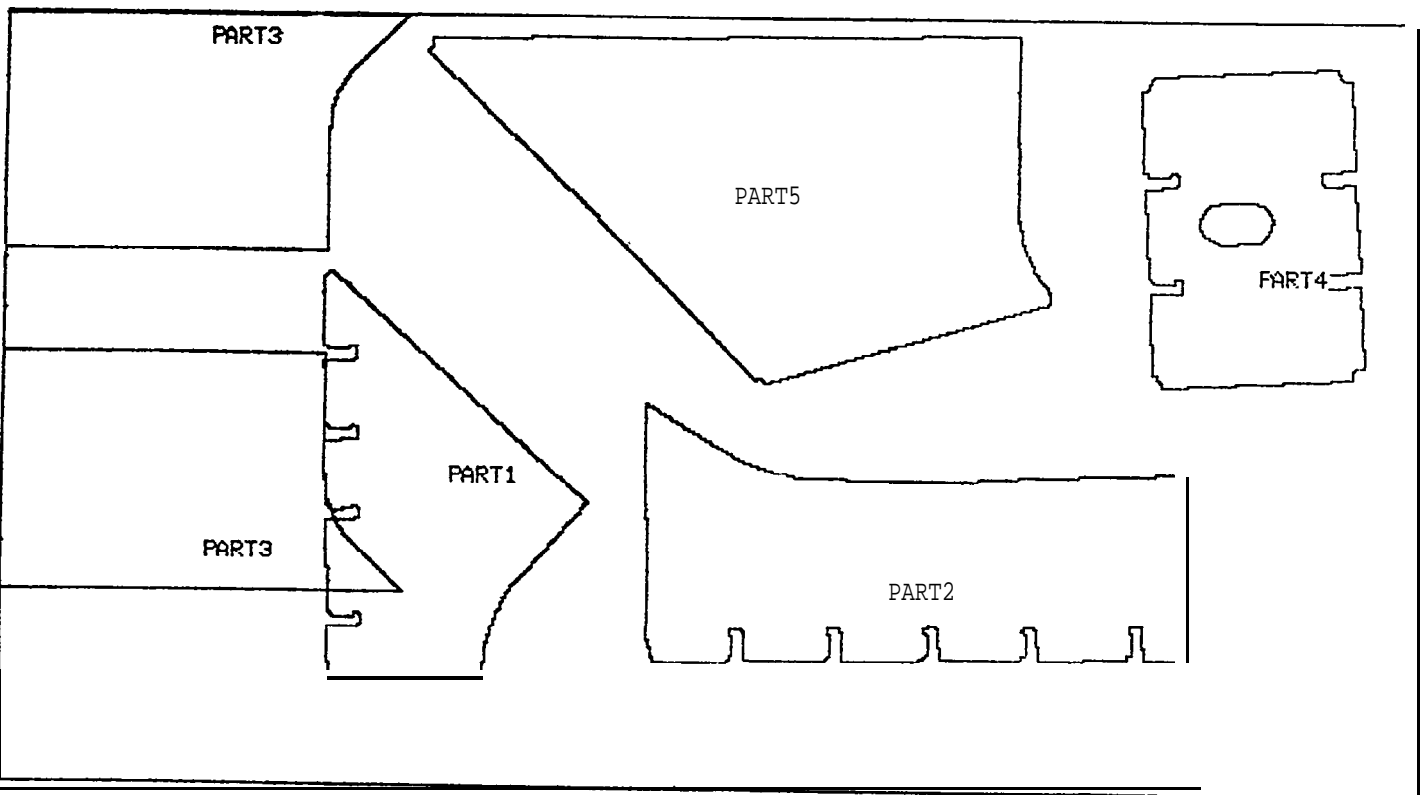
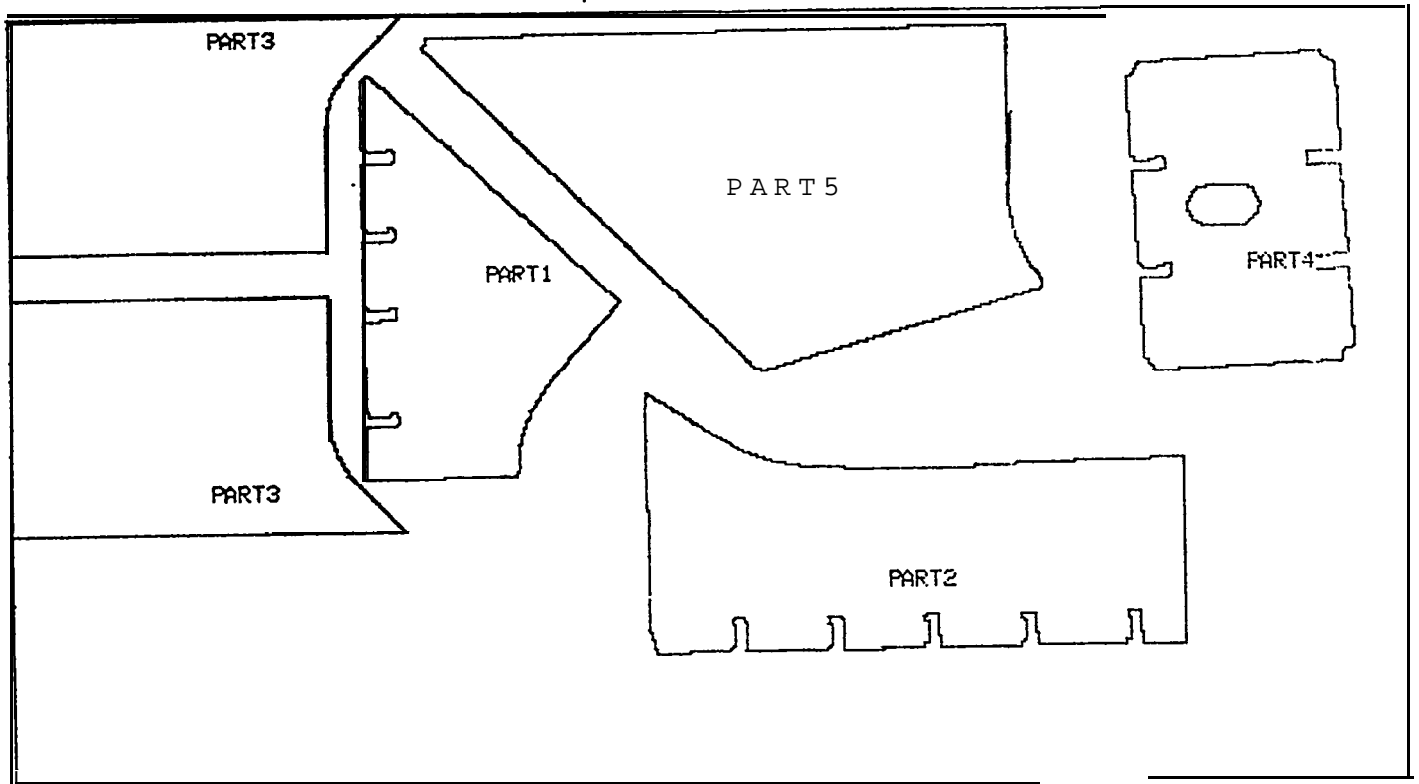
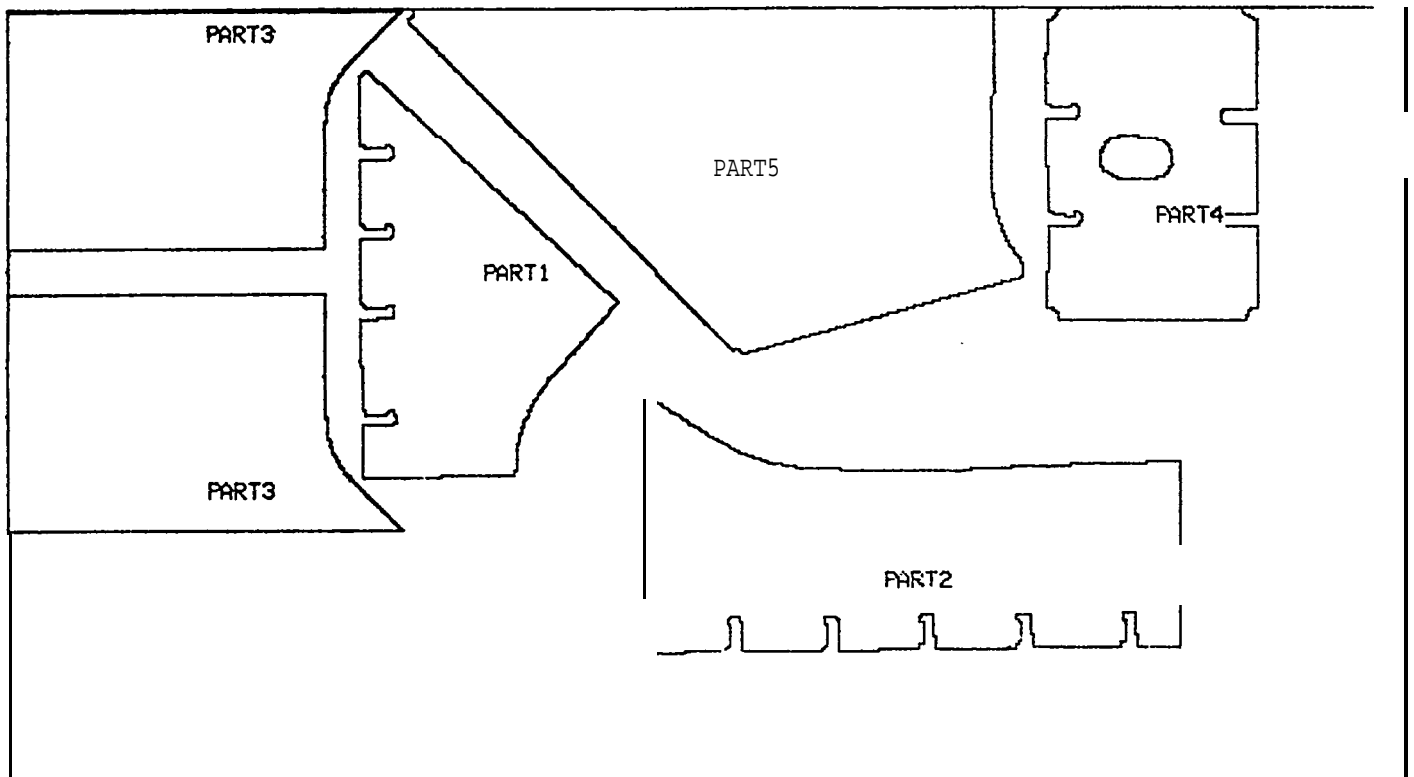


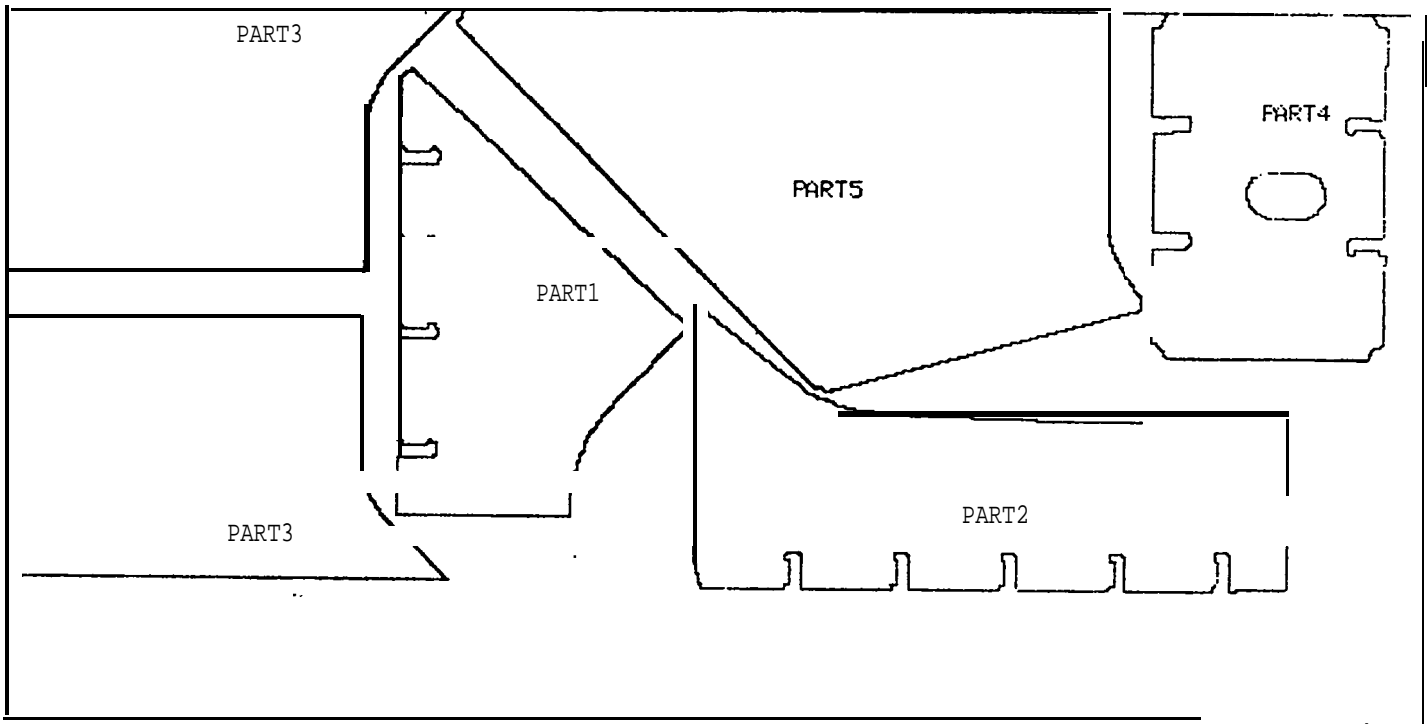
Figure - 14 -  
172



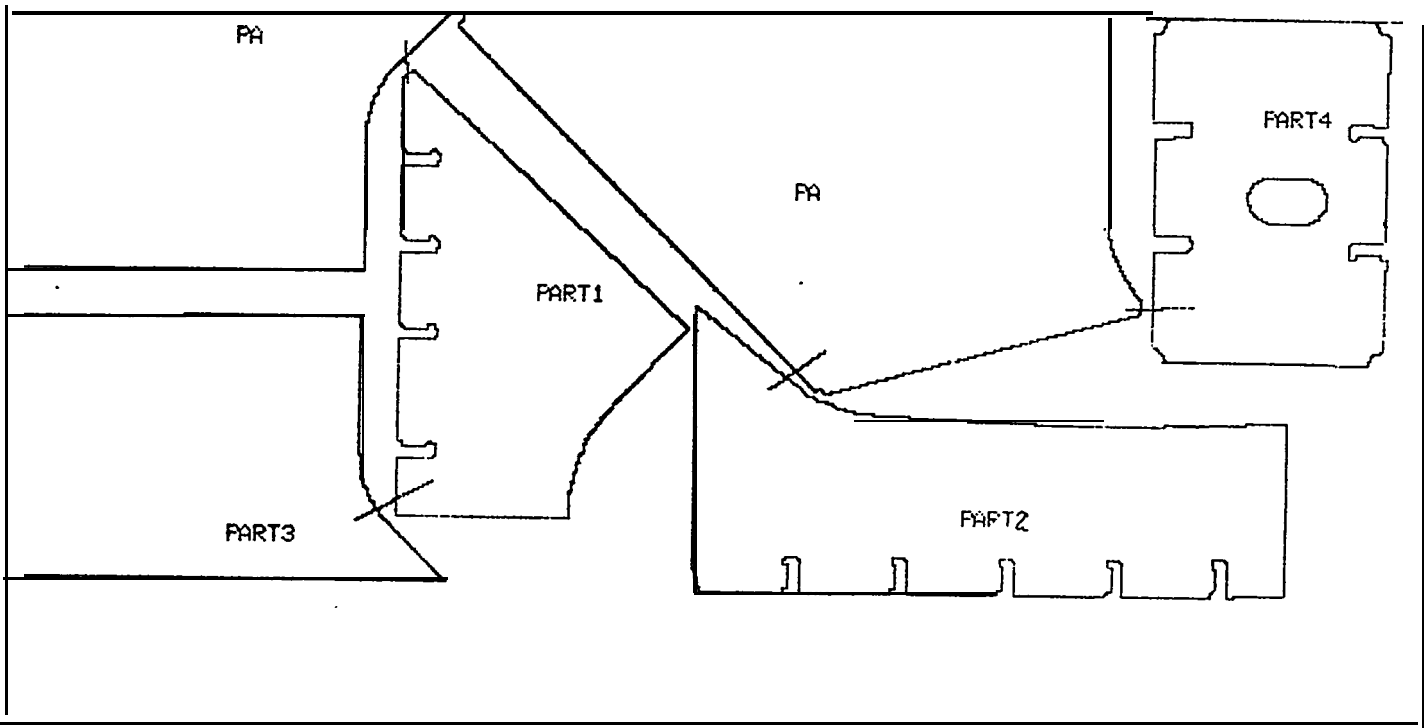
**Figure - 15**



**Figure - 16**

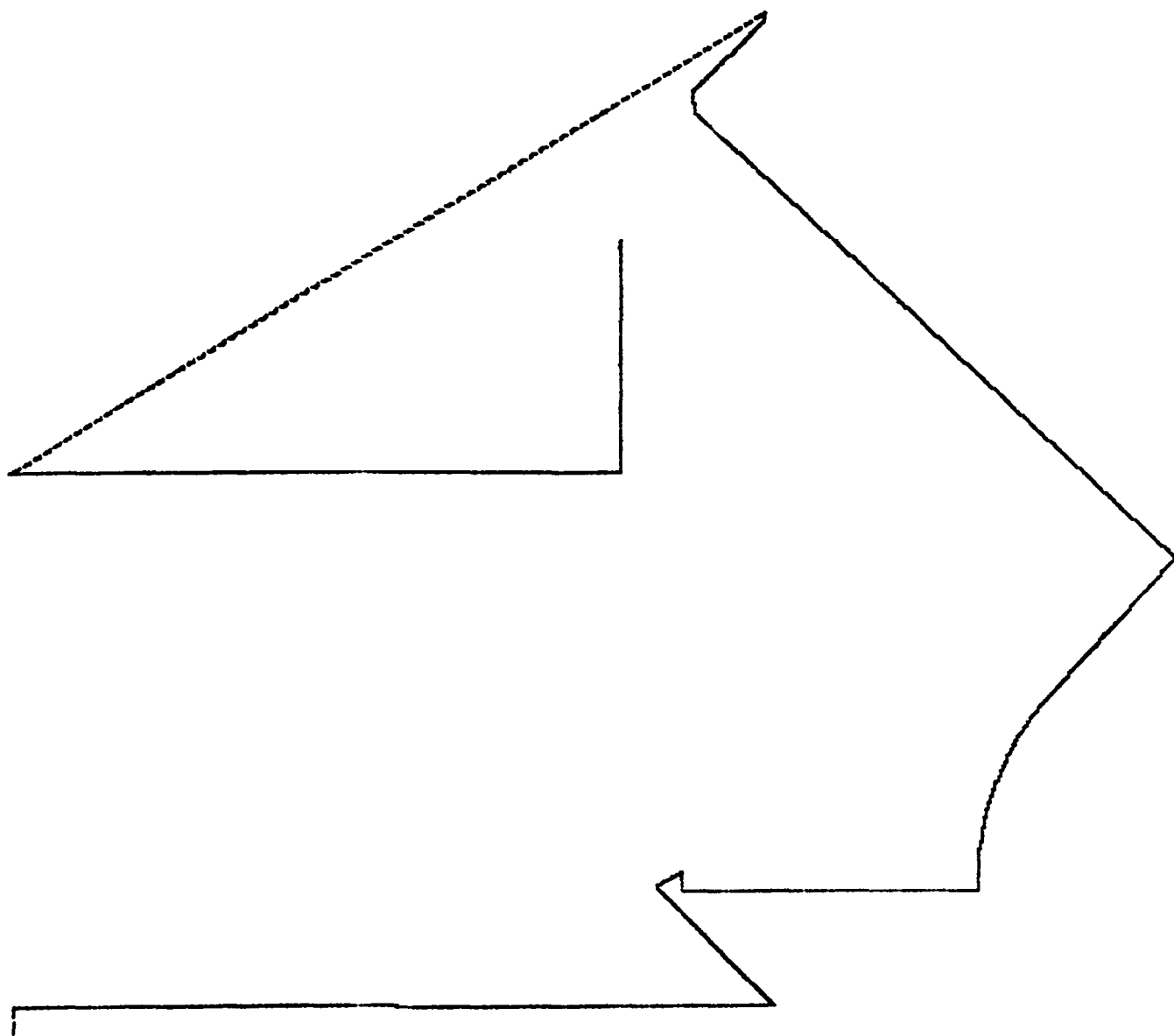


**Figure - 17**



**Figure - 18**





Lunghazza del percorso utensile in lavoro =	6789.	(cutting length in mm. )
<b>Lunghazza del percorso utensile alzato</b> =	2313.	(positioning length in mm. )

Figure - 19

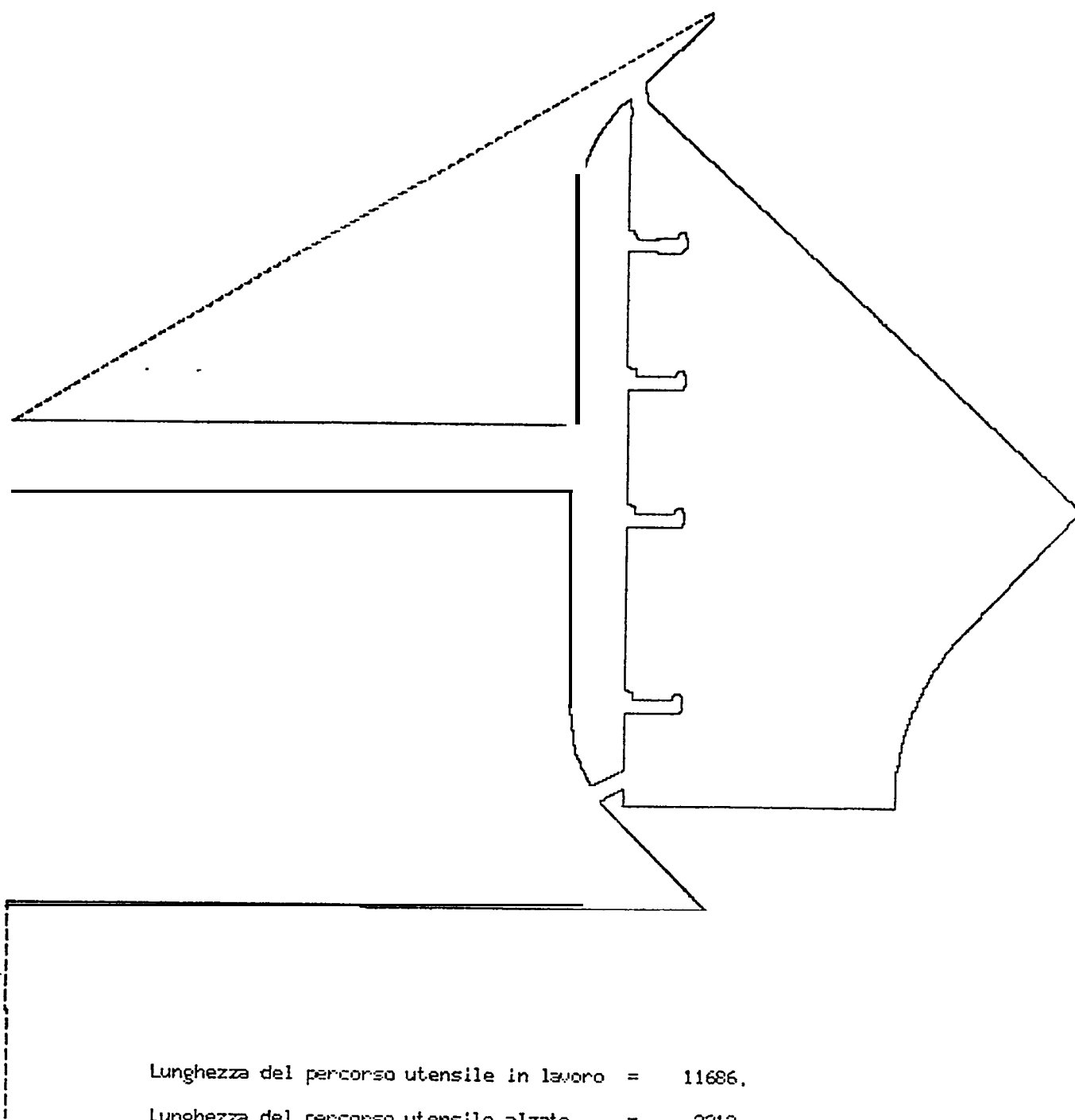
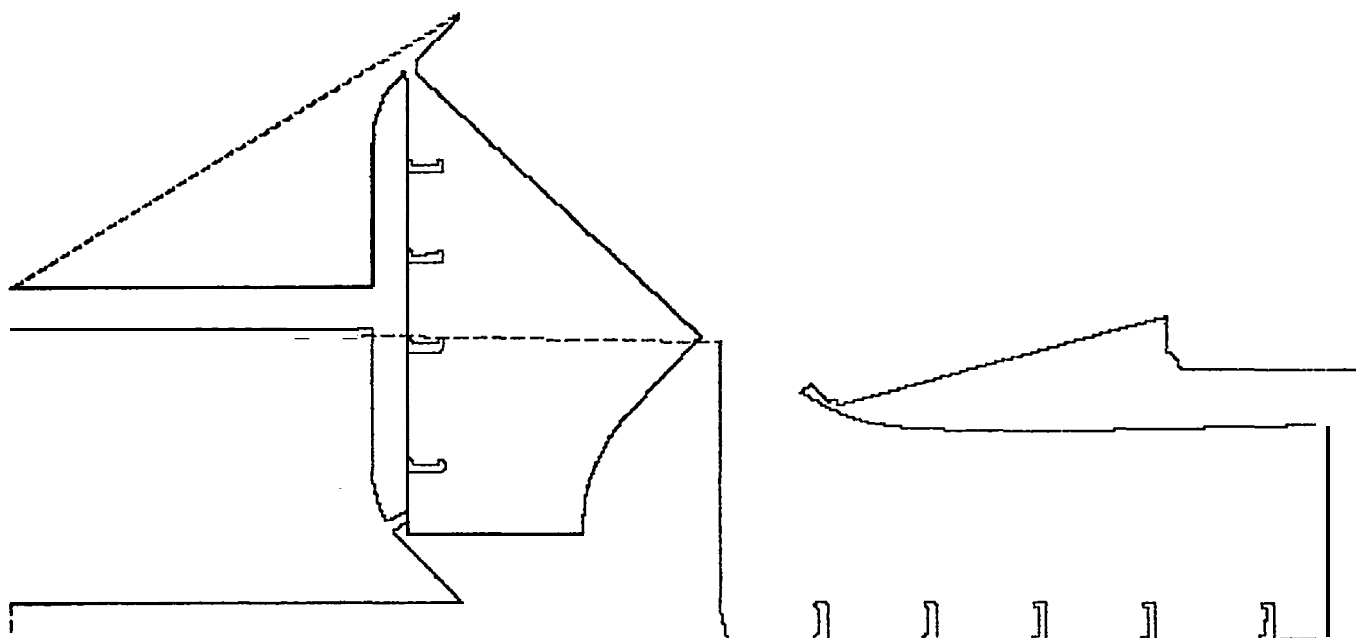
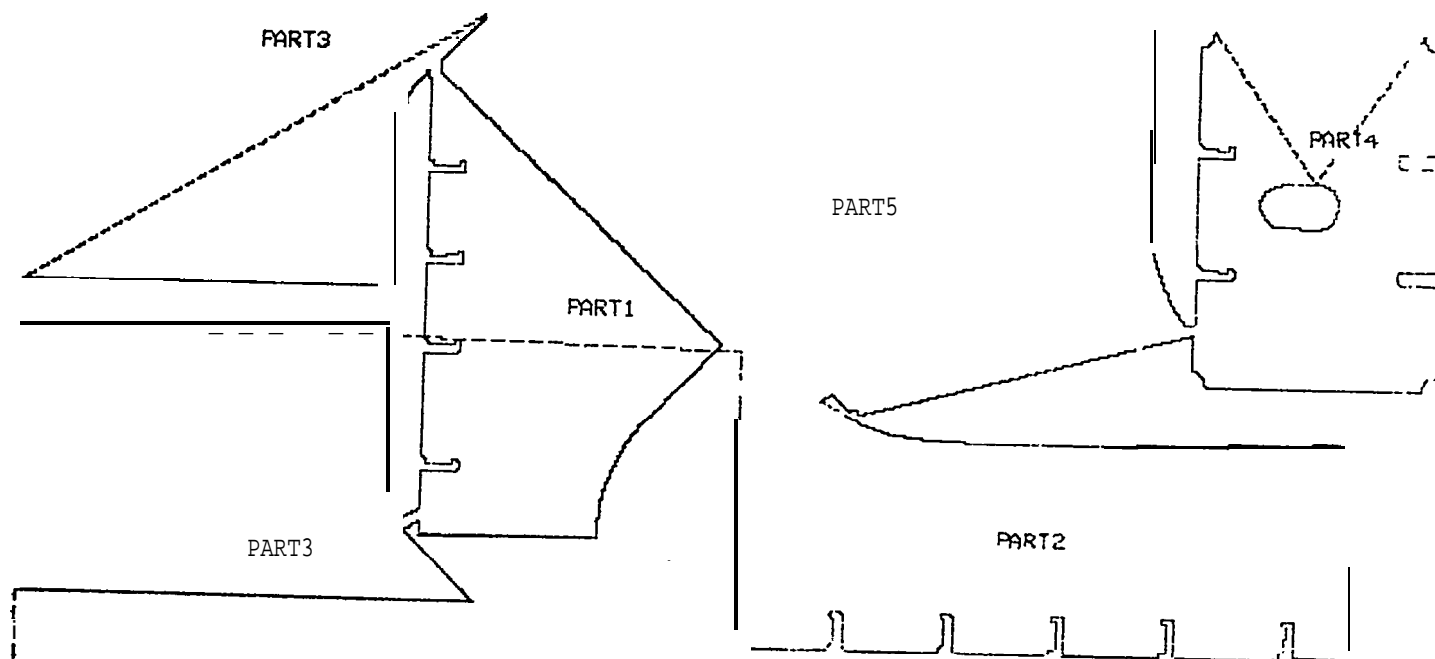


Figure - 20  
176



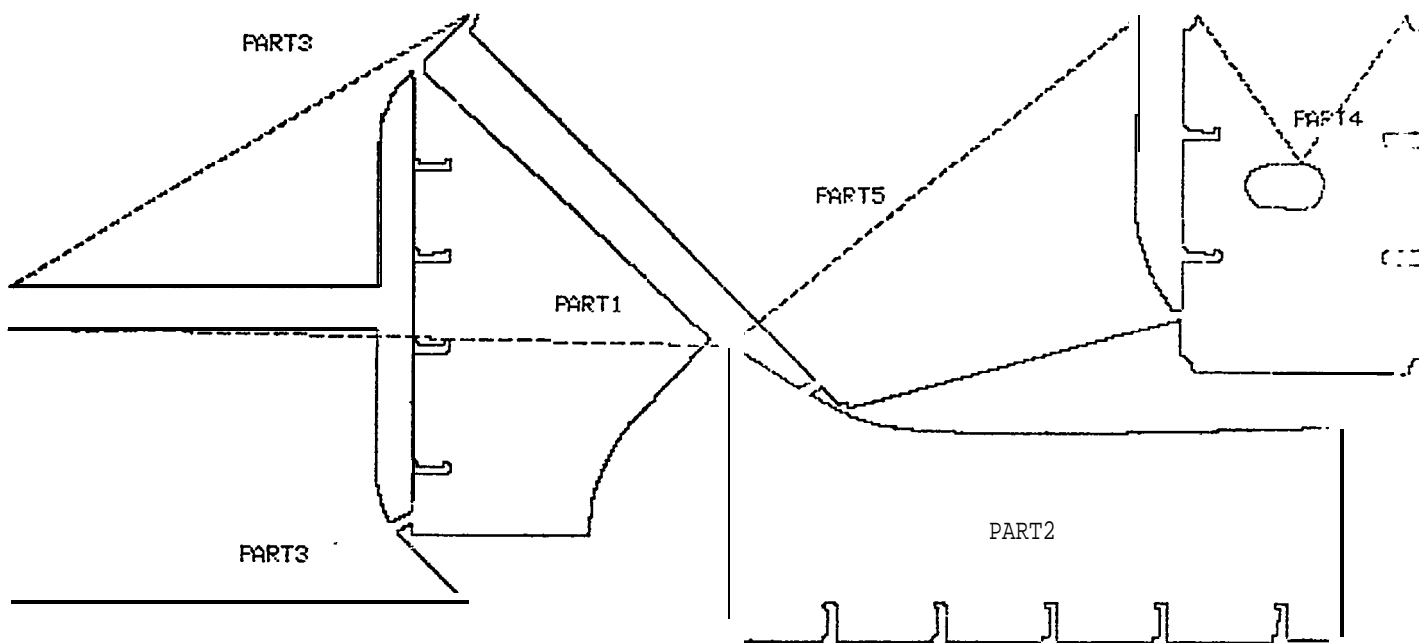
Lunghezza del percorso utensile in lavoro = 21035.

Lunghezza del percorso utensile alzato = 4791,



Lunghezza del percorso utensile in lavoro = 26164,  
 Lunghezza del percorso utensile alzato = 6051,

Figure - 22



Lunghezza del percorso utensile in lavoro = 28264,  
 Lunghezza del percorso utensile alzato = 7858,

Figure - 23

THE ADAGE NESTING AND DRAWING SYSTEM  
SOFTWARE PRODUCT SPECIFICATION  
DESCRIPTION OF PROGRAMS

I. Geometric Package

This portion of the system contains the routines which give the user the following capabilities: (1) to geometrically define those parts not defined by an automatic system (such as AUTOKON), (2) to take existing pre-defined parts and to divide them into smaller, more manageable parts, and (3) edit any previously defined parts, as necessary. Facilities are included which allow the user to set certain parameters or utilize certain functions which make it easy for him to conform to special design rules or fulfill the requirements of good nesting or machining practices.

A. The geometric functions include the ability to:

1. Draw straight lines
  - a. at any angle
  - b. at a constant angle
    - c.  $90^\circ$  to last fixed vector
  - d.  $180^\circ$  to last fixed vector
2. Draw circular arcs
  - a. with a given radius, clockwise from end-point of last fixed vector
  - b. with a given radius, counter-clockwise from end-point of last fixed vector
  - c. with a given radius, tangent to last fixed vector at its end-point
  - d. through three points
  - e. described by given radius and an arc sweep generated by turning a variable control dial
  - f. by fillet at intersection of two vectors
    - constant fillet at subsequent vector intersections
  - h. inside fillet or bead at intersection of two vectors
  - i. constant inner fillet
3. Draw circles
  - a. with arcs' definitions a. through e. above
  - b. with given center point and radius
  - c. concentrically with variable radius about fixed center point

4. Draw eyelets by defining center and radius of major arc and center and radius of minor arc
5. Call out ESSI arc parameters for any arc
6. Draw new part geometry, parallel to old at given offset
7. Draw with perspective projection of a particular contour
8. Selective erase of any line or curve
9. Menu items, which can be any series of geometric definitions grouped together as an entity, such as slots for longitudinal members, which are then available to be displayed at the bottom of the screen to be selected and placed repetitively on the part being designed, in whatever orientation or scale is desired.

## II. Nesting Package

These routines give the user the ability to work from the display console and call lists of previously defined parts to be displayed on the screen, arrange these parts into nests, store and retrieve completed or partially completed nests, edit any nest or parts within a nest, pass auxiliary operation or set-up information to machine tool operator, and to pass cutter-path information back to the host computer for post-processing to produce punched tapes for numerically controlled machine tools.

- A. TRAPART: Transfer parts to be nested from the host computer to the ADAGE GS/340
  1. Uses IDN (Identification No. ) to find parts request;
  2. Searches AUTOKON data base for ESSI parameter list for each IDN;
  3. Calculates the area and center of gravity for each part;
  4. Creates a data file for transmission;
  5. Transmits data to the ADAGE GS/340 to be stored on disc.
- B. NESTING: Performs data manipulation, part set-up and nesting, cutter path definition, and partial post-processing.
  1. Data manipulation includes
    - a. copying of parts at same or different coordinate transformations or reflections
    - b. insertion of new parts or parts from different files
    - c. deletion of parts
    - d. data compression and reduction

**In particular, this part of the program allocates the required work files to the user and prepares the interim or final results to be transferred to the host computer.**

**2. Parts Set-up Operations include:**

- a. Display parts, one at a time, now stored on Adage disc files**
- b. Transformation of a part or set of parts in X and Y and rotation around center of gravity or any selected point**
- c. Preliminary grouping of parts into a set of parts**
- d. Reflection of a part or set of parts**
- e. Placing or deleting a part or set of parts on sheet metal outline**
- f. Duplication of a part or set of parts**
- g. Setting parameters for interference distances and parallel distances**
- h. Replacement of positioned parts with similar parts**
- i. Definition or re-definition of sheet metal outline dimensions**
- j. Calculation of overall efficiency and percent of waste**
- k. Display of stacked sheets of metal (up to eight) so that a particular nesting area is carried through to each sheet.**
- L Definition of any preliminary cuts**
- m. Storage and retrieval of general or non-cutting information for each part**
- n. Output of auxiliary operational information such as, arrangement of metal plates in fixture, number of cuts, description, etc.**
- o. Hard copy output of a detail part or of entire cutting path as well as auxiliary information on each sheet or parts**
- p. Storage of partial or final results on ADAGE GS/300 disc files**
- q. Retrieval of stored partial or final results for completion or modification**

**3. Nesting Completion - Utilizes parts position data to perform the following functions:**

- a. Retrieval from the ADAGE disc files of a nesting to be completed or of a completed nesting to be modified**
- b. Calculation or initial positioning moves**
- c. Calculation of any excess metal to be left on periphery of any part.**
- d. Calculation of scribing path**  
**Examination and modification of cutter path**
- f. Definition of connecting bridges between individual parts**
- g. Insertion of auxiliary and miscellaneous function codes and comments**

- h. Calculation of compensation for width of cutter path
  - i. Provision for eyelets as starting holes for cutting torch adjustment for bevel cuts
  - j. Redefinition of the cutter start point on the circumference of the part, due to machining requirements
  - k. Modifications required to cut different sizes of metal parts
  - l. Automatic summations of cutter path length for both rapid traverse (positioning) mode and for metal removal mode
  - m. Display of all paths
  - n. Measurement and summation of cutter path length for sections to be cut by semiautomatic system
  - o. Display of dimensional measurements for verification purposes
  - p. Storage on Adage disk files of final or partial results
- C. **STONEST:** Restructures and stores interim and final nesting results on host computer files; functions include:
- 1. Translation of incoming data from Adage system
  - 2. Restructuring or identification data to give
    - file name
    - record type
    - record name
  - 3. Storage of final data for each cutter path
- D. **TRANEST:** Transfers to Adage system the data required to complete the cutter path, including the following functions:
- 1. Reading a deck of cards to determine list of items required for transfer
  - 2. Retrieving from host computer data base the interim or final results required
  - 3. Retrieval of required parts from AUTOKON data files
  - 4. Transformation of data and arrangement for transmission
  - 5. Transmission of data to an Adage disk file
- E. **USEDATA:** Utility routines in host computer for:
- 1. File modification
  - 2. File compression
  - 3. Preparation and editing of punched tape for numerical control machine tools (completion of post-processing).



SPADES INTERACTIVE GRAPHICS  
AT AVONDALE

Filippo Cali  
Cali and Associates  
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With over 25 years of experience in the shipbuilding industry, Mr. Cali founded Cali and Associates, a consulting firm for engineering and marine industrial computer applications. Prior to forming his own consulting company, he was Assistant Vice President for Engineering at Avondale Shipyards and Director of Engineering at Litton Ship System. Mr. Cali is a graduate of the Italian Naval Academy.

## ACKNOWLEDGEMENTS

**The development of a production oriented Interactive Graphic version of the 'SPADES' System for N/C Lofting has been a team effort at Cali and Associates, Inc. with the help of Avondale Shipyards, Inc. personnel.**

**Special recognition must be given, however, to Mr. Lonnie Lowery of Cali & Associates, Inc. for carrying out the main development load, and to Mr. Lester Vicknair of Avondale Shipyards, Inc. for his help and dedication to the project.**

**Also, no success would have been possible without the advice and feedback from Mr. Vincent Nuzzo and his people at Avondale's Mold Loft.**

## **GENERAL DESCRIPTION**

**When the decision was made to proceed with the development of the Interactive Graphics version of the 'SPADES' System, a list of requirements and goals was made.**

**One of the major considerations was to have total interchangeability between the graphic and the batch mode of the System such that rework could be processed easily, whether the original work had been done through the 'CRT' or in batch. As much as we would like to think otherwise, experience has taught us that changes and revisions are an ever present way of life during the ship design and construction process.**

**The requirement was also set that none of the 'SPADES' management and control features would be compromised because of the graphic.**

**In order for the graphic version to be a useful production tool, the user would have the capability of totally checking parts and/or burning tapes generated through the 'CRT' without having to wait for a drafting machine drawing and/or computer printout.**

**It was also decided that the user would have the capability of switching from one program to another directly from the tube without re-initializing any program at the central computer.**

**The plans called for four 'CRT's to be on simultaneously, and for at least one batch 'SPADES' program to be also running at the same time. This requirement caused the only major modification of the then existing 'SPADES' System in order to allow different programs to read and write records from the same data base at the same time.**

**I am happy to report that all of the above requirements have been met. Without going into a detailed description, we achieved this by the simple method of modifying the 'SPADES' System to work either in a batch or in an interactive graphic mode. In fact, the same executable module is called for at all times, regardless of the intended mode of processing the data.**

**By combining the use of virtual memory capability of the computer and judicious use of overlay, all the applicable programs have been linked together in one executable module. This was made easy by the fact that all 'SPADES' modules - in addition to using the same input handling routines and post processor - make extensive use, also, of common general routines; and therefore, no incompatibility existed between the various modules.**

At the time the film was taken, the Shell Development Program had not been linked. This has now been done, and the new version including it is in production use at Avondale.

The development of the software started in September, 1974. The first version, including only the nesting, was put into production use in August, 1975, and the entire project completed in May, 1976.

## **HARDWARE CONFIGURATION**

### **I. Mainframe Configuration:**

**IBM 370/158 (Virtual Memory)**  
**Actual Core Allocation - 1.5 Megabytes**  
**Addressable Core Allocation - 16.0 Megabytes**

### **II. Disk Storage Configuration:**

**IBM 3830. Storage Control**  
**IBM 3330 Disk Storage Facility**  
**IBM 3336 Magnetic Disk Pack (100 Megabytes Storage Per Pack)**

### **III. Graphic 'CRT' Configuration:**

**IBM 2840 Display Control Unit**  
**IBM 2944 Data Channel Repeater**  
**IBM 2250 Display Unit (4 Units Per 2840).**

IMPLEMENTING THE U.S. NAVY'S HULL DEFINITION  
PROGRAM IN U.S. SHIPYARDS

John C. Gebhardt

CADCOM, Inc.

Annapolis, Maryland

Dr. Gebhardt is a co-founder of CADCOM and its current Vice President; until August 1974 he served as Director of Technology in charge of all projects. Dr. Gebhardt taught naval architecture at the U.S. Naval Academy. At the University of Michigan he taught experimental ship hydromechanics and assisted in various ship design and test projects.

Dr. Gebhardt designed and directed the development of AUTOTANK, a computer-based system for automating the operation of ship model testing facility. The CADSHIP system is now used by the U.S. Coast Guard to review the structural integrity, damage and intact stability and seakeeping properties of new designs submitted to the Coast Guard for certification. Under his direction a NAVSEC-developed computer-aided arrangements program was implemented on a minicomputer system resulting in increased performance and the unique capability to automatically digitize three-view engineering drawings.

## **ABSTRACT**

**The unified Hull Definition System was designed by the U. S. Navy so that the digital computer could be used to assist in the "fairing" process. CADCOM, Inc. was tasked by MARAD and the Navy with transferring this technology to the U. S. shipbuilding industry. This transfer involves four steps: (1) enhancing the program to make it meet the needs of the industry, (2) generating four standard versions of the program, (3) creating documentation, and (4) conducting training seminars for potential users. The program does not replace the conventional methods of designing hull forms; rather, it functions as an interactive tool which allows the designer to retain control over the surface he is defining. He still performs his traditional procedures, but he performs them more quickly and accurately than before.**

## **I. OVERVIEW**

The job of defining a ship's hull form with sufficient accuracy, precision, and completeness to enable a shipyard to build the ship which the designer had in mind when he developed his lines plan is difficult. Traditionally, the design agent draws a lines plan to a relatively small scale and then gives it to the shipyard as part of the contract plans and specifications package. Upon receipt of the contract, one of the first tasks the shipyard must undertake is to generate a fair, accurate definition of the hull form which faithfully represents the contract lines plan. Before systems such as AUTOKON, SPADES, and STEERBEAR came into widespread use in large shipyards, this task was accomplished by hand on the mold loft floor - as it is today in many small shipyards - by highly skilled shipyard personnel at a large expenditure of time and money.

At first glance, the fairing process seemed to be well suited for computers, and, indeed, since the early 1960s, fairing programs of various types have been used, with varying degrees of success, by U. S. shipyards. Unfortunately, all of the programs currently in use seem to have drawbacks, and none, to our knowledge, has been universally acclaimed as being able to solve all fairing problems.

The basic problem, as we see it, is that there is no unique solution to the typical fairing problem. Put as concisely as possible, the problem reduces to finding a surface which

- (a) passes through some finite number of points
- (b) meets some finite number of global constraints, such as volume, centroid, etc., and

**(c) is judged "fair" by an experienced Naval architect. Obviously, an infinite number of surfaces can meet requirements (a) and (b); and some of these will presumably meet requirement(c).**

**The fact that more than one acceptable solution exists to the problem has led us to the fundamental conclusion that for the digital computer to be useful in the process of full-scale hull form definition, its role must be confined to simulating and enhancing the drawing board/mold loft environment. Such a role will allow the designer/loftsman to perform the tasks and procedures he traditionally performs; but with the use of a computer, he will be able to perform them much faster and more accurately than ever before.**

**Specifically, the ideal hull definition system should have the following basic characteristics:**

- (a) It should create a surface definition from a series of intersecting line segments which lie in the surface.**
- (b) It should be able to produce information about any line which will allow the operator to easily judge whether the line is "fair".**
- (c) It should enable the operator to move point(s) on any line so as to achieve acceptably fair lines.**
- (d) It should be able to output, as a minimum, a complete table of offsets, nes drawing, and the offsets of the intersection of any plane and the defined hull surface.**



- (e) **It** should produce lines that are defined by the mathematical equivalent of the flexible spline normally used by Naval architects and loftsmen.

**At the 1975 REAPS Technical Symposium Mr. M. E. Aughey of the Naval Ship Engineering Center, Hyattsville, Maryland, described a program which essentially meets all of the above requirements. In response to requests by the REAPS participants, MARAD initiated a joint MARAD/Navy effort to transfer this technology-to the U. S. shipbuilding industry. CADCOM, Inc. was subsequently chosen to effect the transfer by performing the following tasks:**

- (a) **Enhancing the program somewhat to make it responsive to the needs of the U. S. commercial shipbuilding industry**
- (b) **Generating four standard versions of the program**
- (c) **Creating full and complete program documentation for the entire spectrum of potential users, and**
- (d) **Conducting training seminars to speed the technology transfer process.**

**Subsequent chapters of this paper briefly describe the program, its impact on current methods and systems, our implementation plan, and future possibilities for the use of the program.**

## **II. HULL DEFINITION CAPABILITIES**

**The Unified Hull Definition System is designed to meet the fairing needs of the U.S. shipbuilding industry for the foreseeable future. The program is extremely flexible and capable of producing accurate and fair definitions of a wide variety of hull forms. The procedure for using the program parallels the conventional methods of designing a lines plan and provides the user with an interactive tool that allows him to control the surface definition until he judges it to be "fair". The program is written in a subset of ANS FORTRAN IV and consists of some 45 modules and approximately 5000 source statements.**

In order for the program to be better suited to perform in a production-type design environment, we have added certain enhancements. These include additional engineering capabilities and modifications that will allow a more efficient user/program interface. The program capabilities, as now implemented, include:

- (1) Production of the traditional three-view lines plan of faired stations (or frames), waterplanes, and buttocks
- (2) Printed output of a full-scale table of offsets, including first and second differences
- (3) production of isometric views of selected lines
- (4) Output of standard hull form hydrostatic characteristics (volumes, areas, centers, etc.), and

(5) Output compatible with AUTOKON E-File

Most computerized lines fairing methods lack continuity and form definition in the longitudinal direction. Stations or frames are defined, but interpolation techniques are required to determine the shape of the hull between frames. Experience has shown that no interpolation technique is universally suitable.

The hull definition program overcomes this difficulty by defining the hull and other surfaces with longitudinal lines as shown in Figure II-1. The shape of any frame or station is then uniquely defined by the connected sequence of the points of intersection of the longitudinal lines at the transverse plane of the frame or station. The tool used for connecting the points is the mathematical batten in the form of a parametric spline with slope and curvature continuity. The mathematical lines defined by this parametric spline are computed and used in the endpoint-tangent or segment form. Each segment of a line (between points) is described by X, Y and Z coordinates and tangent vectors at each end.

To utilize the program, the designer must define his hull form through the use of control and other lines in the procedure shown in Figure II-2. These lines are the boundaries between hull sections with continuity in slope and curvature. They will include, on a standard form, the center line profile, deck-at-edge, flat of side and bottom areas, half-siding and any knuckles or chines. These lines will be fixed early in the hull definition process and will act as the reference lines between which all fairing is done.

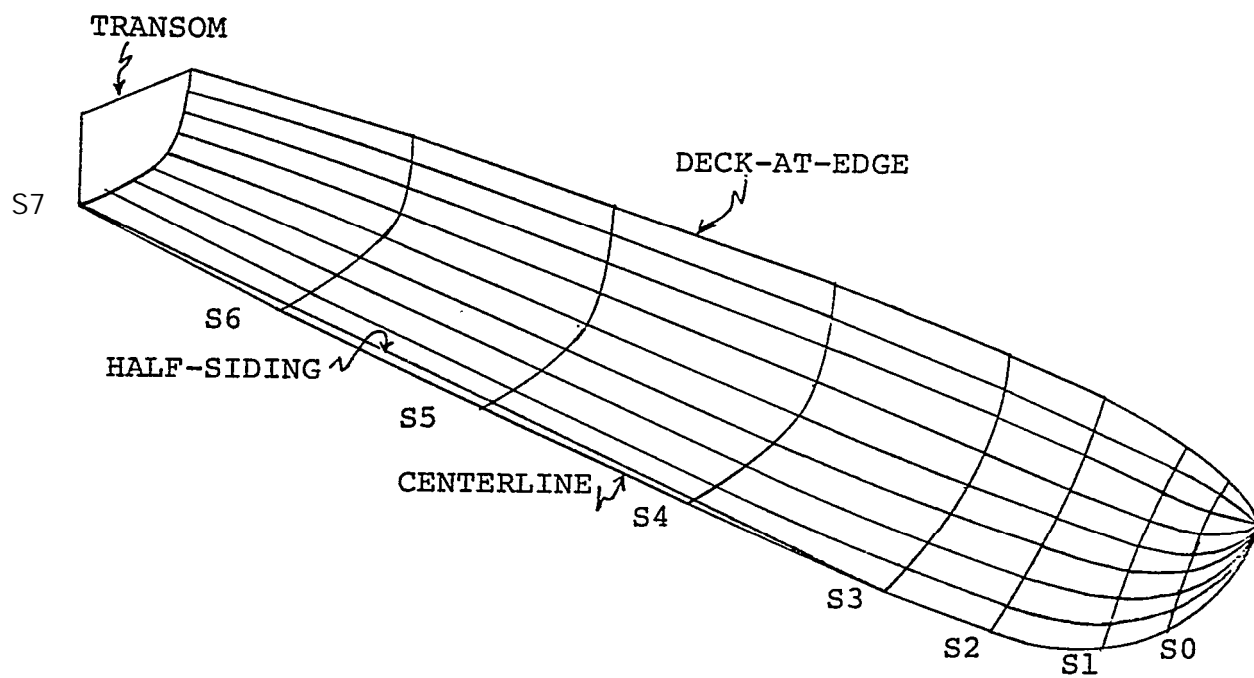


Figure II-1  
Port Half-Shell View

Program Flow Diagram

Design Agent

Shipyard

Modify points  
until satisfied

Modify lines  
until satisfied

Modify points  
until satisfied

Prepare Contract Lines Plan and  
Establish Baseline Design Hull Form  
( $C_D$ ,  $C_V$ ,  $C_R$ , LCB, B, L, T, etc.)

Contract Lines Plan

Chose control lines to  
describe the hull form and prepare  
for input to Hull Definition  
Program

Fair control lines using  
first & second differences

Plot differences

Plot control lines

Add offsets of stations

Run program to fractionalize girths  
and convert all points to longitudinal  
lines describing the surface

Fair iso-girths using  
first & second differences

Plot differences

Run check of  $C_P$ ,  $C_B$ ,  $C_X$ , LCB, B, L, T, etc.

Plot waterlines, buttocks, body plan

Print offsets

Create AUTOKON E-file

Once the designer has faired the control lines, he enters a "rough" set of stations to provide a general definition of the hull surface. By dividing each station or "girth" into equal "girth fractions", he can, through the program, pass a parametric spline from bow to stern through points of equal percentage. These is o-girth lines are the lines he will fair. Enough is o-girth lines must be used to sufficiently define all regions on the surface, but no more than necessary should be used.

The designer can, as a program option, fair a portion of or a complete iso-girth, station, frame or control line. By observing the plot of the second differences of any line, he can manipulate the points for re-input into the program to produce a line that suits his notion of "fair". Throughout the fairing process he may request a print of the standard ship hydrostatic characteristics to ensure that his manipulation of the hull surface remains within the design parameters.

As you can see, the designer retains control over the surface he is defining. He can stop the fairing process at any point to check his design parameters, and through the use of available output options, he can satisfy many of the hull design report requirements in the construction process.

### III. THE IMPACT ON CURRENT OPERATIONS

#### III-1 Hardware Requirements

The Unified Hull Definition Program is written as a stand-alone package which can be implemented on a wide variety of modern computer systems. Memory requirements vary depending on the target machine. However, the program has been successfully implemented on a minicomputer with 64K bytes of memory. The important factors which will determine the success or failure of the implementation at any particular facility are:

- (a) The availability of a drafting machine and/or CALCOMP-compatible plotter
- (b) The average turn-around time at the facility, and
- (c) The availability of an on-line graphics terminal, such as a Tektronix 4010, to preview hard copy output.

It must be emphasized that the hull definition software is very interactive in nature and can be utilized most effectively when the operator can get fast response from the computer both in terms of printed output and plotted results. Hence, the shorter the time required to obtain a plot, the easier it is to use the program.

CADCOM is currently modifying the graphic output to make it compatible with all plotters and drafting tables which can handle input data in the ESSI format. In addition, CALCOMP-compatible plotters will be supported by the software, and either EIA or ASCII codes may be specified as program options.

In order to take full advantage of the ESSI plotters to plot circular arc segments as well as straight lines, we have developed an algorithm which will replace all parametric spline segments with a combination of straight lines and circular arcs within a specified tolerance.

### III-2 An Interface to the AUTOKON System

To further enhance the utility of the Unified Hull Definition software in shipyards which are now using or are planning to use the AUTOKON 71 system, we have designed a program option which will be supplied with each standard version of the program. This option will build a replica of the so-called E-File, which is normally generated by the AUTOKON FAIR-2 module. This data can be subsequently used by the two AUTOKON modules **DRAW** and **TRABO**, as shown in **Figure III-1**. **DRAW produces an ESSI element paper or magnetic tape for plotting standard AUTOKON outputs on a drafting machine. TRABO TRANSfers the BODyplan data in the E-File into the permanent AUTOKON database.**

The data required by AUTOKON from the fairing module (either the Hull Definition Program or FAIR-2) consists of, at most, the following:

- (a) The main dimensions of the ship, that is, i.d. rise of floor, bilge radius, max height, max half-beam, etc.
- (b) Transverse frame definitions
- (c) Waterline definitions, and
- (d) Buttock definitions.

The Hull Definition Program will generate an E-File containing the above data which, to the other AUTOKON modules, should be literally indistinguishable from an E-File generated by the standard AUTOKON fairing module. 198



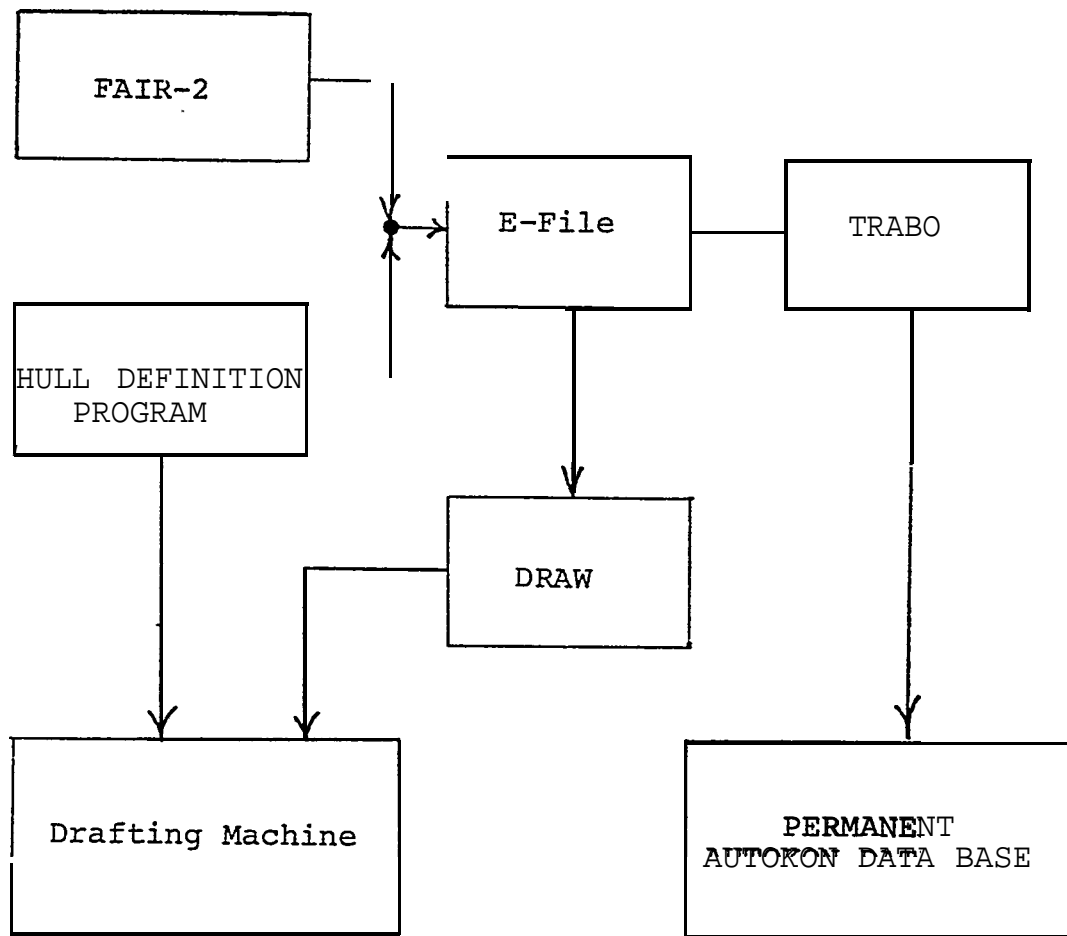


Figure III-1  
The Hull Definition Program/AUTOKON Interface

#### IV. IMPLEMENTATION PLAN

**The successful transfer of the Navy-developed hull definition program to the shipbuilding industry will depend heavily upon the training in program usage and maintenance received by the shipyards. We envision that three types of individuals will be directly involved with the program at the shipyards; therefore, we are designing the documentation and training information to reflect the specific needs of each type.**

**Designer's, user's and programmer's manuals are being written to cover each of these expected areas of involvement. These manuals will not only explain the basic concepts of hull definition and the information needed to perform the design functions, but will also provide the user with the details required to interact with other individuals involved in the hull definition process.**

**In order to assure a smooth implementation, CADCOM will conduct a workshop later this year so that potential users may become familiar with the program. The workshop will consist of two separate meetings held approximately one month apart, with the first one now scheduled for late October. This first session will consist of a lecture-discussion - which will include a Presentation of basic concepts, user options, and input and output procedures - followed by a question-and-answer period and demonstrations of the program applied to typical fairing applications. If possible, hands-on experience will be provided.**

Each participant will be provided with a training manual which will include sample problems and visual aids. In addition, each participant will be provided a source deck of the program and complete documentation and installation instructions.

The follow-up workshop session will be held for the purpose of answering questions and providing guidance in the use of the program after participants have had an opportunity to install and utilize the program at their own facilities.

## **V. POSSIBLE FUTURE DEVELOPMENTS**

The programs which will result from this project should meet the majority of the requirements of U.S. shipyards for the foreseeable future. At the same time, the appearance on the scene of such a flexible, versatile, unified tool for surface definition opens the door to many possibilities for enhancing and optimizing other aspects of ship design and construction. One development which we believe will have a significant impact on the way ships are designed and built should occur gradually as design agents find that they can design new hull forms from scratch using this program more quickly and easily than they can manually. If the shipyard that then-builds the ship also used the Hull Definition Program to fair the contract lines, the design agent can transmit the lines plan to the shipyard as a deck of cards which can be checked for any "shaggy" spots that the designer did not catch. These spots can be tidied up very economically.

At the present time several enhancements are in various stages of development. If added to the program, they could enhance its capability by providing the following:

- (a) a developable surface module generating a ruled surface between any two control lines
- (b) a curved plate development module for generating an expansion of any portion of the hull surface
- (c) an interface module for creating data bases for other shipbuilding systems, notably SPADES and STEERBEAR

- (d) an implementation of the program on a minicomputer-driven interactive graphics CRT Terminal, with 3-D curve visualization capability and on-line, interactive modification of offsets in response to first and second difference displays, and
- (e) Canned fairing algorithms for automatically "fairing" lines or families of lines that are almost fair.

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## AUTOKON AT A SMALL SHIPYARD

Jesse Harkey  
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Currently a Mold Loft Superintendent, Mr. Harkey's responsibilities include manual lofting and N/c system operation. Before joining Port Weller Dry Docks, he was an N/C programmer with Litton Ship-Systems and COM/CODE Corporation.

The following information is not only a collection of ideas used in the original implementation of Port Weller's computerized numerical control system, but also contains some of my own opinions of how and why a computerized mould loft is an essential part of a productive and progressive shipyard. Some of these ideas, naturally, would have to be altered to suit each particular shipyard, but the basic philosophy of simplicity which Port Weller used should be applied in all shipyards. I hope to explain why this is so important not only for us - the small shipyard - but also why it is essential to the medium to large yards as well.

There are two general subjects that will be covered in this paper - justification and implementation. The justification will be brief and figures represented in this portion are not actual figures obtained from Port Weller records, but are superficial numbers used only to give the basic ideas of how the eventual purchase of the Autokon system was justified at Port Weller Dry Docks.

The implementation portion will be an actual account of our use of numerical control programming starting from December 1973, when the part and nest programs were first obtained from Shipping Research Services.

## JUSTIFICATION

Justifying a computerized N/C system is actually accomplished by a very simple formula. The first thing that must be determined is in what areas money can be saved by using N/C tapes and how much money it will take to implement and maintain such a venture.

The most obvious way that money can be saved by using N/C programs is in steel preparation, fabrication and erection. A small shipyard would, for instance, produce approximately 10,000 tons of steel per year. If you used a figure of 50 manhours per ton, that gives you a total of 500,000 man hours per year, and using a \$10.00 hourly rate, that comes to 5 million dollars per year in steel *manhours*. In other words, it takes only one per cent reduction of man hours in this area to produce \$50,000.00 in savings. Now all that must be done is to come up with a realistic budget to find out what per cent must be saved to justify changing to the new system.

The following is a breakdown of the minimum requirements for installing a computerized N/C system:

N/C Burning Machine

Automatic Drafting Machine

Computer Terminal



**Key Punch Machine**  
**Office Space and Furniturb.**  
**System Supervisor**  
**Equipment Operator**  
**Computer Programs**  
**Training**

**The following ideas will be based on the supposition that a shipyard is to put the use of an N/C system through a trial period of one year.**

**The N/C burning machine will probably be the most difficult to justify because it would have to be purchased and it represents the largest capital investment. (This is assuming the N/C programs will be leased).**

**The cost of buying and installing a burning machine is in the neighbourhood of \$150,000.00 which includes the cost of a director at about \$30,000.00. These costs are based on the idea of buying only the basic 4 torch, 40 bed. I do not believe that it would be wise at this point to get involved in rotating heads for beveling and a 3 axis machine is, in my opinion, an unwise investment and should not be considered for shipbuilding applications.**

This cost, however, should not be considered an investment entirely committed to this venture. The only portion that would be lost if the N/C System failed would be the cost of the director, as the burning machine could certainly be utilized in burning rectangular plates or converted to optical burning if you use that particular lofting procedure.

The acquisition of a drafting machine and computer terminal can be done by leasing with an option to buy. This type of arrangement was available in 1973, and I assume that this is still possible at this time. The configuration of this equipment will be discussed in more detail in the implementation portion of this paper.

There are two computer systems available that are suitable for shipyard applications. They are commonly known as the "Autokon" system and the "Spades" system.

A license for the use of Autokon in the United States can be obtained from the Maritime Administration, Washington, D.C. **Related, system support and program training is available from the REAPS Program staff, and production services can be acquired from Shipping Research Services, Alexandria, Virginia.**

**The Spades system can be obtained from Cali and Associates, Metaoroe, Louisiana. They offer, as well, program training and production services.**

**The other items listed should be self-explanatory and will not be discussed any further at this point.**

The cost of installing a computerized numerical control system should come to a total cost of about \$400,000.00 for a one year trial period. As discussed earlier, \$120,000.00 of the cost for the burning machine should be excluded for the purpose of calculating the percentage of savings needed to justify this system. This leaves us with an expenditure of only \$280,000.00 - or a reduction of 5 to 6 per cent in steel man hours to justify this project,

**Based on the achievements at Port Weller Dry Docks, a six per cent reduction in steel man hours can be considered only a moderate degree of success. After a similar trial period described above, the management of Port Weller approved the purchase of all the Autokon programs and the automatic drafting machine. We have also added a second numerical control burning machine and built new office facilities for the part coders.**

After the signing of a contract to build an Arctic Class bulk carrier, the acquisition of Alkon part programming and Prelikon (design programs related to the Autokon system) were approved by management. The training for these programs has been completed and no serious problems have been encountered. The approval of purchase for these programs can only be attributed to the financial success of computerized numerical control at Port Weller.

## **IMPLEMENTATION**

**The installation of the computer programs should be a very simple task - have this done by the people the system was obtained from. There is no need to be concerned about making the programs work for you since this has been done for a number of years by many shipyards using the same system.**

**It is very important that you realize that there is absolutely no reason to have a system analyst (computer programmer) at your shipyard for implementing or using the programs. A shipyard will have all the assistance needed from the supplier.**

**The system supervisor should be someone with experience in the N/C programming field - preferably in the system you intend to use - but not absolutely necessary. I believe that this person should be carefully chosen and he must have the necessary backing from the manager of production.**

**The personnel to be trained in the programs should be well qualified in three areas - blueprint reading, general shipbuilding knowledge, and layout - before he or she is trained to be a part coder.**

**The loftsmen, of course, is the most logical tradesman for this job, but we have had success with the experienced plater**

and shipwright as well. More than half the knowledge required for the part coder job is already achieved by these craftsmen. This is really a big advantage as well because the basic training of these people can be achieved in only a few weeks. This is a big advantage for the plater as well, because with the introduction of an N/C system a shipyard will not need as many platers as required with any other loft production method. This system should be an integral part of the full scale loft. It is very easy for the part coder to supply the ship with stiffener lengths, templates or lengths for face flats and templates for brackets related to the parts he has coded.

The loft should have the following personnel:

Validator - 1 for every 4 - 6 coders

Nesters - 1 for every 8 - 10 coders

Manual Loftsmen - 2 for each 8 - 20 thousand tons per year

Part Coders - 6 - 8 for each 8 - 10 thousand tons per year

These figures may have to be altered slightly depending on the type of vessel being built and the amount of success the coders have in using the programs.

The personnel required to operate the terminal, drafting machine and key punch should be limited to one for each 6 - 8 coders. Port Weller has used the services of a part time employee for these tasks during vacation times or times where the work load is heavy and difficult to handle by one person. This is an important job and the individual hired for this position must be dependable and competent. A log of all programmed parts and the filing of program decks can be done by this employee as well.

The office space for the terminal, drafting machine, key punch and active records should be well planned and must be environmentally controlled. This room should be entirely separate from all other functions, and traffic in this area should be kept to a minimum. An ideal location for this room is the existing loft since you will not need as much area for full scale lofting once the change has been made to computerized lofting.

The automatic drafting machine should not pose a big problem because there are only two companies with extensive experience in the verification of numerical tapes. They both offer shipbuilding verification software and adequate service is provided by both. A wide variety of table sizes are available from both companies, but I can see no reason for having a drawing surface more than 4 feet by 5 feet. The larger tables are much more expensive

**and have no particular advantage to justify this extra cost.**

**The remote terminal can be a very difficult problem because of the many types available. Port Weller has had excellent service from Data 100 of Minneapolis, but each yard will have to make a choice depending on the service available locally.**

**Both suppliers of drafting machines offer remote terminals and this could be a very good solution, but the availability of quick service should be weighed carefully.**

**The installation of a computerized numerical control system involves some very important decisions, but the task can be achieved if you take the time to evaluate the experience of others. There are many times that we benefit from the mistakes as well as the success of others.**



## NASA'S DISSEMINATION OF TECHNOLOGY

Louis N. Mogavero

NASA Headquarters

Washington, D.C.

Mr. Mogavero is the Director of NASA's Technology Utilization Office where he is responsible for the transfer of NASA's aerospace technology to nonaerospace uses. Prior to joining NASA, Mr. Mogavero owned an aluminum specialty company, then worked in aerospace production control and engineering. He also spent ten years developing new products for the Boeing Company.

When I first began to think about how I would describe NASA's Technology Utilization Program, it seemed to me that what was missing was the reason we have such a program, that is to say, what are we trying to accomplish? And equally important, I should say a few words about the effectiveness of our program, the things we have accomplished and the lessons we have learned from both our successes and failures. Let me begin by describing how the program got started.

The NASA aerospace transfer process began as an experiment. This experiment was initiated by the law that created the National Aeronautics and Space Administration in 1958 with a specific provision directing NASA to provide "for the widest practicable and appropriate dissemination of information concerning its activities and results thereof." From this directive a very important question evolved. "Could technology developed for one purpose be successfully applied to other applications?" Put another way, "Could aerospace technology provide solutions to non-aerospace problems?"

If this experiment proved to be successful, then the return to the economy and to the taxpayers whose investment supported NASA's missions would be pure profit. Assuming that the research and development costs supported NASA's primary space and aeronautics missions, then any secondary use of this technology for other non-aerospace purposes would provide an additional benefit to our national economy.

Well, today after approximately 14 years of experience with this program, we can hardly continue to call it an experiment. It's a firmly established program that is alive, growing and constantly changing to meet new demanding challenges. The exciting thing about this program is that the exploration of space and the advancement of aeronautics generates innovations in almost every field of science and technology and, therefore, provides us with the broadest possible technical base to stimulate progress in areas not even remotely connected to the original research. Spinoffs of technology have ranged from medical devices for the handicapped to patching materials for street maintenance and countless applications in between.

It's easy to see why this experiment prospered. The technology was there in almost every field imaginable and the problems were there in both government and private industry. All that was needed was some kind of dedicated effort to bring the two together. The connector in this case is NASA's Technology Utilization Program.

First let me describe this program in broad, general terms before I give you some examples of actual transfers. The program is divided into three major activities, each structured to reach a specific group of people in order to let them know, first, technology exists that may be of value to them and, second, it is available.

Our technology data base consists of 1,300,000 items and is growing at a rate of 70,000 items per year. As new innovations are developed they are screened to identify those which may have some potential for non-aerospace applications. Each innovation is described in a one page "Tech Brief," which is sent to people who have asked for information either for their own personal use or for subsequent publication in various technical magazines and journals.

This type of dissemination is understandably broad in nature and is somewhat analogous to seeding the land. You are sure some seeds will take hold, but you never are sure where. So we decided to focus our efforts on the industrial sector for the obvious reason that industry is the most active user of technology. To accomplish this we established a national network of dissemination centers to serve industry by searching what has become the world's largest data bank of technical information. The network of centers includes the University of Connecticut, Research Triangle Park in North Carolina, University of Pittsburgh, Indiana University, University of New Mexico and the University of Southern California. The network has access to more than eight million documents and is growing at a rate of 50,000 documents each month. It contains about 800,000 space-related reports as well as ten times that many documents from private and non-governmental sources. The *range* of information covers air pollution, chemicals, education, engineering, nuclear energy, food, textiles, metallurgy, medicine, business, and economics.

You can see, there is a pretty good chance the network can locate information that can be of value to the people looking for solutions to their problems. Several thousand companies now use this service annually. I think it's important to mention that we understand the competitive environment we are working in and, therefore, throughout our negotiations the proprietary interests of the user are scrupulously protected. Technical information that has been provided through this network has resulted in many useful applications and new products. I'll mention some examples a little later.

One special center in this network, called "COSMIC", is located at the University of Georgia. I should spend a few moments to describe this center because its activities are very closely related to CAM-I's. COSMIC stands for Computer Software Management Information Center, and it contains one of the nation's largest software libraries of engineering analyses programs. This center provides, at a fraction of their original costs, computer programs developed not only by NASA, but also by other government agencies. A large percentage of these programs can be incorporated directly into existing commercial or educational operations with little or no modification. Over 1,600 programs are currently being carried by COSMIC with the potential for application to problems in pollution control, health care, law enforcement, energy, manufacturing, communications, construction, consumer products, transportation, agriculture and, of course, computer technology.

What I have talked about so far, relates basically to industrial applications specifically but more generally to the private sector of our economy. The public sector presents an entirely different set of problems, both technically and operationally. By "operationally" I mean the mode in which one operates to bring technology to bear on public oriented problems. For example, in most cases state and local municipalities, particularly the smaller cities and towns, have limited research and development organizations or facilities to experiment with technology. Even more important, few have the capability to match current needs with currently available technology. We at NASA recognized this latter deficiency as a primary target for our transfer activities and, therefore, we created applications teams. These teams,

located throughout the country, work with public sector agencies in public safety, transportation, urban construction, and biomedicine, defining significant public problems that might be solved by adopting aerospace technology. Now, the important difference between this program and the others I mentioned, is that in the private sector, the person with the problem--that is, the user--usually applies the technology to suit his own needs; while in the public sector, the technology must be reengineered or redesigned for a specific application before it can be turned over to the final user. Very often this process involves not only applications engineering, but development, evaluation and finally field testing the prototype hardware. The difference here is that in the private sector we pass on technology. In the public sector we pass on hardware that demonstrates the application of technology.

Basically, this is NASA's Technology Utilization Program, but I haven't talked about the value of the program. Every program can be **measured by a bottom line and we define our bottom line in one word - benefits!** What was the use to which the technology was put? Who did it benefit and how? I would like to show you a 12 minute film that describes some of these benefits. After the film I'd like to make some concluding comments.

(12 minute film - "Partners with Industry")

I hope this film has given you a better understanding of what we try to accomplish. You will remember that I said earlier we measure our progress and effectiveness by the benefits derived from the transfer of aerospace technology. One of our frustrations is that we don't always know how the technology we furnished to various people was actually used. Sometimes even the user doesn't connect our information with its ultimate use. But we do know that our efforts have paid off for improved inorganic paint to help protect coastal bridges from seawater corrosion; flat wire mounted on the outside of walls and **floors instead of in them; studless winter tires that remain pliable** in sub-zero degree weather; detection of bearing defects particularly in railroad wheel bearings ; waste heat recovery from furnace flues using pipes and a risk management system to help prevent catastrophic

fires in liquid natural gas plants.

Last year economists at Mathematical, Inc. , Princeton, New Jersey, selected four spinoffs from aerospace technology and estimated their return to our national economy. The benefits from these four areas alone--integrated circuits, gas turbines used for electric-power generation, a structural analysis program, and insulation for cryogenic uses--calculated into the 1980's, amounted to \$7 billion! We think this is a strong indication that applying technology to other than aerospace uses pays off and more importantly, pays off in the right places--the people who paid for the technology in the first place.

One last comment, we have felt for a long time that we could do much more in the field of manufacturing productivity and more specifically, the application of computer technology in this field. NASA and CAM-I have found an area where we believe our combined talents could be applied to our mutual benefit. This project, jointly supported by our two organizations, is our first step in this direction and if it proves successful, as we believe it will, we will then continue to explore other similar areas over a much broader field of applications so that we can convert our national investment in aerospace research and technology into spinoffs that improve your job, your health, your home, your environment, and your future.

AUTOMATION AND PRODUCTIVITY  
IN  
DISCRETE PART MANUFACTURING

John M. Evans, Jr.  
National Bureau of Standards  
Washington, D.C.

Dr. Evans joined the National Bureau of Standards in September 1970 as a program analyst in the Office of the Director of the NBS. He transferred to the Institute for Computer Sciences and Technology of NBS in 1972 and became Deputy Manager of the Office of Developmental Automation and Control Technology when it was formed in 1973. In that capacity he manages the development of guidelines and standards for computer aided design and manufacturing systems to benefit both government and industry.

He received his B.A. degree in Physics from Yale University in 1964 and his Ph.D. in Physics from the University of Colorado in 1970.

The subject of this conference is automation and productivity in shipbuilding. I am going to talk about automation and productivity in the general context of discrete part batch manufacturing, which includes shipbuilding, to try to provide a wider prospective on the technical strategies that are being used in applying automation in manufacturing, their impact on productivity enhancement, and the wider economic implications of enhancing productivity.

My program at the National Bureau of Standards is the Automation Technology Program. Our program is designed to assist other Government agencies in applying computer-based automation systems to meet their mission objectives and to develop standards, guidelines, and performance measures which will assist Government and industry to effectively use automation systems to improve productivity and improve job safety. It is from this perspective that I would like to speak to you this morning.

### Productivity

The primary motivation for using automation in manufacturing is to increase productivity. Why is productivity important? There are three basic reasons why productivity is important to the economic health of the United



States that have been emphasized by the National Productivity Center, the Department of Commerce, and the General Accounting Office.

First is international trade. We are running out of basic materials, and find ourselves in an increasingly competitive marketplace to obtain the raw materials we need in our economy. Of course, petroleum is the obvious example of our increasing dependence on other countries, but there are many other materials for which we are even more dependent on foreign sources. For example, we import 100% of the chromium, cobalt, manganese, and tin that we use. In return for these raw materials, we basically trade agricultural goods and products from our discrete part batch manufacturing industries. For this reason, the efficiency of those industries is of crucial interest to the well being of the country, as reported by the Comptroller General of the United States in a recent report to Congress.

The second reason that productivity is important is inflation. The Secretary of Commerce has given testimony to Congress, pointing out that productivity is the only source of real increases of wealth in the economy. Price increases not resulting from true increases of output are simply inflationary. In fact, the negative correlation between price increases and productivity increases, on an industry by industry basis, is very strong. Data developed by the Bureau of Labor Statistics and published by the National Commission on Productivity (now the National Productivity Center) shows clearly that those industries with higher increases in productivity tend to have lower increases in prices, and those industries with low increases in productivity tend to have higher yearly price increases.

The third reason that productivity is important is that productivity is the basic source of increased real consumable wealth. The correlation between real compensation per man hour, that is, wages after subtracting the effects of inflation, and output per man hour, that is productivity, is again very strong. Productivity increases result in real wage increases, and the labor unions recognize this, and generally support the concept of increasing productivity.

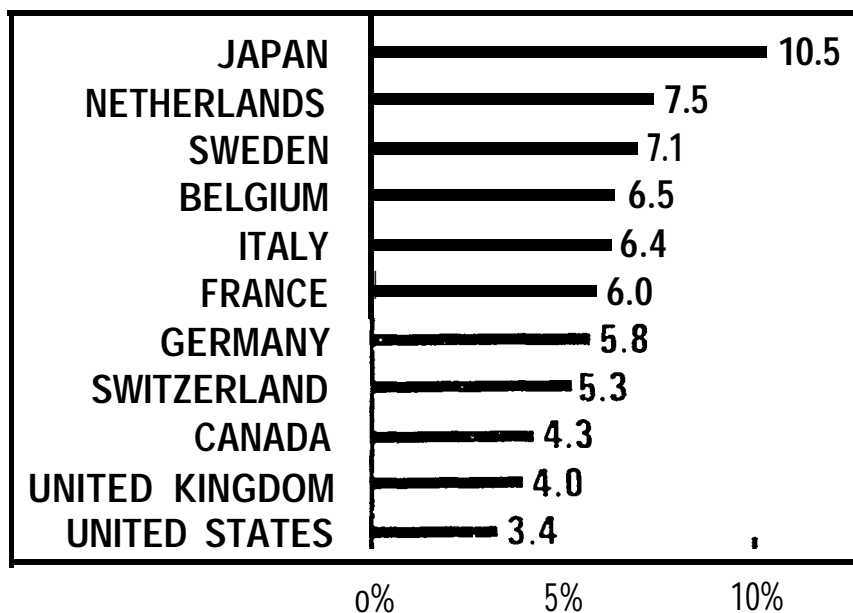
If productivity is thus so important., how are we doing? The answer is that we are not doing very well. When compared with the rate of productivity increases of all of our competitor nations in the free world, the United States has ranked the lowest in terms of increased productivity in recent years. Specifically, during the period between 1960 through 1973, the average annual increase in output per man hour in the United States was 3.4%. This should be compared with increases in Germany of 5.8%, France 6.0%, and Japan of 10.5%. The question that we must address is what we can do to improve our performance in increasing productivity. (See Figure 1.)

#### Productivity Increases Through Automation

Automation can significantly improve productivity in manufacturing. To consider the specific technologies of automation, we must distinguish between different types of manufacturing industries. All manufacturing industries may be divided basically into three classes, each with a distinct and identifiable process technology, that is, a distinctly different means of manufacturing their products.

# PRODUCTIVITY GAINS

## OUTPUT PER MAN-HOUR RATES OF CHANGE 1960-1973



SOURCE: U.S. DEPT. OF LABOR

FIGURE 1

Yearly average productivity increases for eleven countries, 1960-1973. The United States had the lowest rate of productivity increase during this time period among all of these competitor nations.

The continuous process industries, such as petroleum, chemicals, steel and other primary metals deal with a continuous flow of materials such as a flow of liquid or a continuous strip of paper. The continuous process industries account for some 47% of the value added in manufacturing. The remaining 53% of our manufacturing industries are discrete part industries in which the products are individual items such as airplanes or transistors.

Within discrete part manufacturing industries it is possible to distinguish between mass production, such as automobiles or consumer appliances, which use well known techniques of assembly line and transfer line production, and discrete part batch industries where products are made on general purpose machines in small lots or batches ranging from sizes of one to several hundred-thousand. These batch manufacturing industries account for 75% of the dollar value of discrete part manufacturing, \$137 billion in value added in 1973, and the greatest potential for improving productivity through the application of the computer lies in these industries.

If you go out and visit typical discrete part batch manufacturing industries in the United States, you will find that the technology is virtually unchanged from that used in World War II. That is, we mostly cut metal parts on manual machine tools, we inspect those parts by hand, and we assemble them by hand.

Some 25 years ago a new technology appeared for discrete part batch manufacturing, based on the application of a computer to control the motions of a general purpose machine tool. This new machine tool is called a numerically controlled machine tool, or **NC** machine tool, because the motions of the tool are controlled by numbers on a paper tape or in the memory of a control computer. One can change the part being manufactured by simply changing the part program,

that is, the numbers on the tape or in the computer memory. NC machine tools typically increase productivity by a factor of 3 or more, that is 300%.

This experience of increasing productivity is borne out by our experience in our own instrument shops at NBS, where we have four NC machine tools and one NC inspection machine in operation. For example, we manufacture authorities. A full set of these weights made with NC machine tools cost **\$700**, one third the cost of a set made with conventional tools. Again, a mirror mount is a typical low volume product made in our shops. When made with NC, a mirror mount costs \$62. When made manually, it used to cost over \$200. These figures are typical of industry experience with numerical control.

The application of exactly the same principles of computer control to manipulators for materials handling and assembly operations has resulted in this technology of industrial robots. That is, the motions of an industrial robot are controlled by numbers in the memory of a control computer.

The greatest gains of productivity come from integrating general purpose programmable machine tools with general purpose programmable materials handling systems to create integrated manufacturing systems. A typical example is the Fujitsu Fanuc factory in Japan where eight NC lathes and an industrial robot are all operated by a central computer in the production of stepping motors. Increases in productivity in such integrated manufacturing systems range up to 2000% and more.

## Integrated Manufacturing Systems

This, then, is the primary point that I would like to emphasize: that the trend in discrete part batch manufacturing is toward integrated manufacturing systems, where computer controlled machines are integrated together with higher levels of computer control into highly automatic computer aided manufacturing systems.

Let's examine a few examples of the state of the art in integrated manufacturing systems around the world.

An example of an advanced integrated manufacturing system in the United States is the Kearney and Trecker Flexible Manufacturing System installed at an Allis Chalmers plant. In this system the operators get instructions from CRTs displaying instructions from the computer. Following those instructions, the operators set up the next work piece on pallets, which are loaded onto robot carts. The robot carts move the parts around the factory to the correct machine tool where they are registered, the pallets are automatically loaded into the machine tool, and the correct machining operations are carried out under computer control. At the end of the tool cycle, the part can be moved to another machine or can be returned to the set-up area to be unloaded.

The use of fixed pallets for holding parts has been dominant in the machinery industries in building integrated manufacturing systems.

The most advanced existing manufacturing system in the world is considered to be the Fritz Heckert plant in East Germany. Like the Kearney and Trecker system, this system consists of general purpose machine tools and inspection machines linked together by automatic materials handling systems. In this system, the pallets holding the work pieces are moved around on air bearing ways with linear induction motors, a concept that rivals some of the most advanced concepts in transportation systems at the current time.

The most advanced proposed concept in integrated manufacturing systems is the Japanese Methodologies for Unmanned Manufacturing Systems, or MUMS program. This program, which is funded by the Japanese Government at a level of \$113 million, has as its goal the development of an automatic prototype unmanned factory for producing parts for machine tools. The concept is a series of machine tool cells linked together by a materials handling system. The materials handling system is in two levels, one level carrying palletized parts and the second level carrying palletized tools. Both the parts and the tools are to be loaded into the machine tools by computer controlled robot systems. The increases in productivity in this prototype plant are expected to be 7000 to 8000 percent.

The Japanese are also exploring the use of robots in automatic assembly. A recent Kawasaki film shows a research laboratory with ten robots of the Unimate type assembling small gasoline motors for, of course, Kawasaki motorcycles.

The ultimate goal in automation in integrated computer aided manufacturing systems is to link the higher level design and management processes together with the systems actually controlling the machine tools.

We can now create systems where a man can sit at a graphics terminal and design a part. The data base that is created in the computer describing that part can then be used to produce drawings on computer controlled drafting boards and to produce the computer programs or punched tapes for operating the machine tools. Eventually, design, process planning, and scheduling and control will all be integrated together with machine tool control systems in an overall integrated system.

The most ambitious concept of this type at the present is the Air Force Integrated Computer Aided Manufacturing Project. This program, which is approved by the Department of Defense at a level of \$100 million, has as its goal advancing the generic technology for discrete part batch manufacturing, and demonstrating that technology in a specific area of sheet metal fabrication and assembly, obviously an area of fundamental interest to Air Force procurement.

#### Architecture of Computer Aided Manufacturing

The way in which the various modular components of computer aided manufacturing systems are linked together is a subject of great current debate, and, indeed, is the subject of the first phase of the Air Force ICAM program.



Every industry can tell you what a computer aided manufacturing system is. The problem is that each one has a different basic concept of what the modular components of that system are and how they are linked together. In addition, a further problem comes in considering the relationship of the host computer system to the applications programs that are the CAM system.

Recently, concepts of CAM have been based around the idea of a centralized data base, with its own data base manager, maintaining all of the data files for the various applications programs in an application independent format. This allows maximum flexibility in writing and integrating various CAM applications programs into an integrated system. However, fourth generation computer systems are likely to be highly distributed, with both distributed processors and distributed data bases. The question of interface standards that are required to integrate various modular components of CAM systems, both hardware and software, now becomes a crucial issue in the development and widespread implementation of CAM systems. It is this area that is of fundamental interest to our program at the National Bureau of Standards.

## Summary

In conclusion, what we are talking about here is computer aided manufacturing: technology to increase productivity. With potential productivity gains of hundreds or even thousands of percents, why haven't we done better in applying this technology?

The General Accounting Office has identified high costs and lack of understanding of the technology and its implications as the principle reasons for the slow diffusion of advanced manufacturing technology.

The National Bureau of Standards is attacking these problems by providing guidelines and case studies to help Government and industry understand the technology, and by developing the standards, the performance measures and the technology to reduce the costs of procuring and using NC and CAM technology.

1. The application of computers can improve productivity in **dis-**crete part batch manufacturing, including the shipbuilding industry, by up to thousands of percent.
2. The lowest levels of computer aided manufacturing consist of machine tools and computer controlled materials handling systems such as industrial robots.
3. A dominant technical strategy that is emerging in the automation of discrete part batch manufacturing is the integration of automated computer controlled materials handling systems with NC machine tools.
4. The greatest gains in productivity will come with the eventual integration of the higher level management functions and computer aided design with the computer systems actually controlling the machine tools and robot systems.

The fact that people are arguing about particular details of CAM systems is not nearly as important as the fact that there is a coherent technical strategy emerging in the field and that the economic payoff in existing applications is enormous.

The important thing for your industry, then, is not so much which particular system to buy, but, rather, to get started, to get on the learning curve, and to start reaping the gains in productivity that will help both your industry and the overall economy of the country.

SHIPBUILDING EQUIPMENT AT MITSUBISHI

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PART I

Shipyard Applications of the Mitsubishi

Horizontal Fillet Welding Robot

## 1. HULL BLOCK ASSEMBLING AND DEVELOPMENT OF ROBOT

A hull structure consists of various parts, but the same type of structure exists enough many in a ship parallel part compared with fore and aft ship parts.

As we can see on Fig. 1 showing a midship section of a tanker, the lattice structures with longitudinal frames and transversal webs are welded to panels of hull plates and deck plates at the parallel part of a ship. This lattice structure is assembled into blocks at the assembly stage and are erected on berths or building docks.

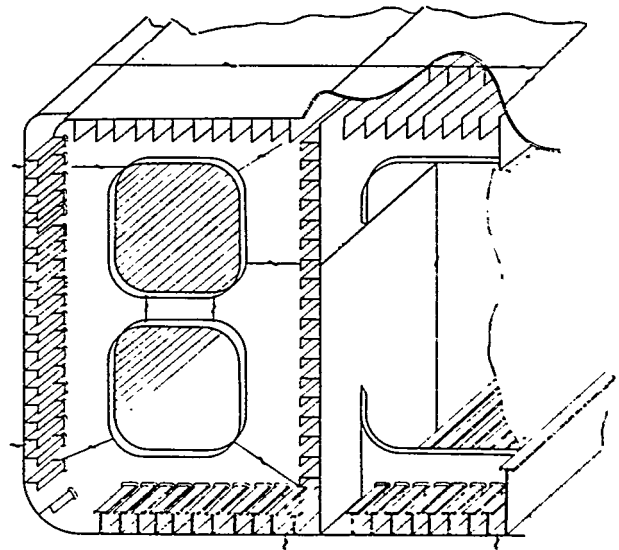


Fig. 1 Midship section of parallel part (150,000 DWT tanker)

Table 1 Welding length of hull construction (150,000 DWT tanker)

Welding Structure	Sub assembly stage							Assembly stage							Erection stage							Total				
	Fillet welding						Butt weld.	Fillet welding						Butt weld.	Fillet welding						Butt weld.					
	D		V		O			D		V		O			D		V		O							
	L	%	L	%	L	%	L	%	L	%	L	%	L	%	L	%	L	%	L	%	L	%				
1 Fore curved part	349	7.2	30	0.6	4	0.1	34	0.7	321	6.6	101	2.1	20	0.4	12	0.2	49	1.0	12	0.2	10	0.2	47	1.0	989	20.5
2 Parallel part	863	18.0	73	1.5	11	0.2	83	1.7	793	16.4	249	5.2	50	1.0	30	0.6	126	2.6	32	0.7	25	0.5	122	2.5	2457	50.9
3 Aft curved part	307	6.4	26	0.5	4	0.1	29	0.6	282	5.8	89	1.8	18	0.5	11	0.2	44	0.9	11	0.2	9	0.2	43	0.9	873	18.1
4 Upper structure	160	3.3	14	0.3	2	-	15	0.3	147	3.0	46	1.0	9	0.2	6	0.1	46	1.0	12	0.2	9	0.2	45	0.9	511	10.6
Sub Total	1679	34.8	143	3.0	21	0.4	161	3.3	1543	31.1	485	10.0	97	2.0	59	1.2	265	5.5	67	1.4	53	1.1	257	5.3	-	-
Total	2004							41.5	2184							45.2	642							13.3	4830	100

D. : Downward  
V. : Vertical  
O. : Overhead  
L. : Welding length in 100 m

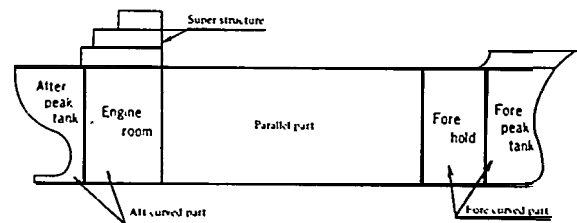
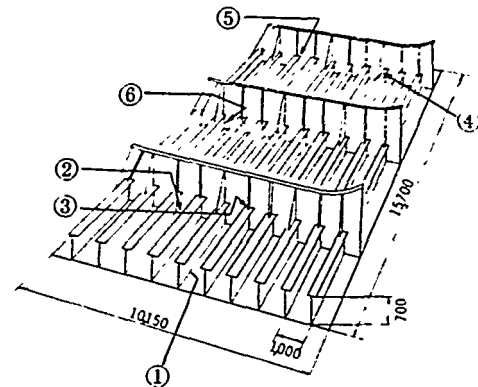


Table 1 shows the percentages of each welding length in various building stages of a 150,000 DWT tanker. Welding length at the parallel part reaches about 50% of whole length for a ship of which 45% is welded at the assembly stage. Table 2 shows each welding joint length of panel blocks of a 150,000 DWT tanker bottom shell block in the assembly stage. Lattice horizontal fillet welding length reaches about 70% of the whole welding length at this stage, though percentage might change in accordance with block's size.

Table 2 Example of various welding joint length of panel block in assembly stage (15QOOWDt tanker bottom shell block)

Welding joint	Welding position	Weld. length/block	Robot appliable weld. length
① Frame × panel	Downward	314	314 m
② Web × panel	- " -	48	48
③ Stiffner × longi. face	"	14	
④ Bracket × longi. face	- " -	20	
⑤ Rib × longi. face	- " -	15	
⑥ Frame × web	Vertical	90	
Total		501	362

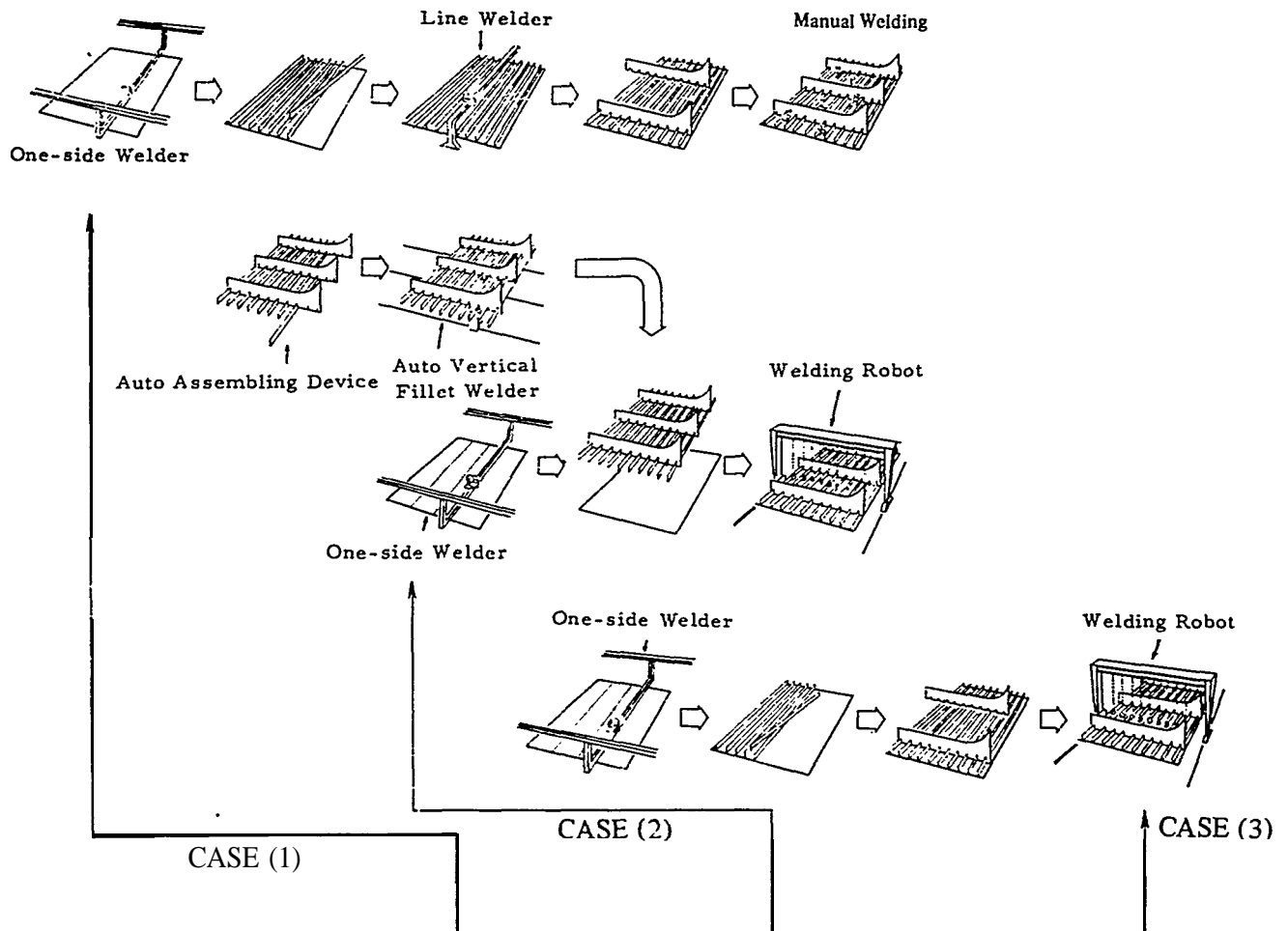
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So far, we have adopted the gravity welding for this horizontal fillet welding with one man six or seven welding machines. But, because of the shortness of the welding length and the occurrence of non-welding part or repair of joint part of welding rod in the gravity welding as well as of the growing need of operation of high intensity, automatic welding of high efficiency has gradually come to be sought after.

The welding system newly developed by M.H.I. consists of a lattice horizontal fillet welding robot, which enables continuous automatic MIG welding on the circuit of the lattice, and a handling apparatus which controls many robots. By pushing the button on the handling panel, the operator can throw the welding robot into the lattice, and thereafter, the robot goes along the walls and repeats the change of direction automatically at each corner. Upon finishing the circuit welding, the robot returns to the indicated position to be lifted automatically by the handling apparatus and moved over to the next lattice. With this system, it is possible to designate the shape of the lattice and the leg length of each side beforehand. Furthermore, such function as start, stop, detection of the non-welded part of the frame (scalops, slots), intermittence of the welding arc and emergency stop can be performed automatically. Thus, the welding robot takes the place of man in the whole welding process of the horizontal fillet welding joint in the lattice.

Table 3 Panel block assembling method and automatic welding



Assembly method		Using line welder	Lattice assembly	Individual disposing
HOW TO AUTOMATE	Panel joining	Automatic submerged arc one - side welding 100%		
	Horizontal fillet welding of panel to frame and web	Line welder 84%	(a) Gravity welding 0% (b) With small submerged arc welder 63% (c) Welding robot 99%	
	Vertical fillet wg of frame to web	Manual welding 0% (difficult to automate)	Automatic vertical fillet welder 90%	Manual welding 0% (difficult to automate)
Advantage		1) Possibility of high efficiency welding of horizontal fillet welding of frame to panel	(1) High productivity in case of using method (b) or (c). (2) Possibility of using key slot.	(1) Small space and investment. (2) Possibility of using key slot.
Disadvantage		1) Increase of total wg. length due to use of collar plates. 2) Medium automation grade considering whole assembly stage. 3) High investment.	(1) Necessity of assembling tables. (2) High investment for automatic assembling device.	Long time to assemble

Remark : % shows rate of automation



Table 3 compares production stages from the view points of assembly methods and welding automation. The panel joining is almost 100% automated by means of the one side automatic welding technique, however, the automation of vertical fillet welding is difficult to realize in case of (1)\* and (3)\*. On the other hand, the welding robot is effective for high efficiency of horizontal fillet welding in case of (2)\* and (3)\*. The robot enables almost perfect automation of assembly and welding of panel blocks with utilization of automatic lattice structure assembling devices (to insert longitudinal frames to transversal webs) and of automatic vertical fillet welders.





\*Note:

- (1) Assembling of longitudinal frames to panel plates, then assembling of transversal webs, attaching transversal webs to already assembled frames/panels.
- (2) Assembling of lattices with longitudinal frames and transversal webs, then attaching assembled lattices to panel plates.
- (3) Disposing longitudinal frames on panels, then disposing transversal webs on them.

## 2. Welding Robot

### 2.1 Principal Function

Principal function and characteristics of welding robot are as follows.

- (1) While maintaining the wire aiming point and the speed of the tip of the welding torch at the corner equally with the straight line part, change of direction is repeated to allow the directed lattice shapes (four kinds, , , , ) to be welded and the welding to be stopped automatically.
- (2) On each side, either one of the designated leg length of the two stages is selected automatically as preset.
- (3) Such non-welded parts as scallops and slots etc, are automatically detected to make possible intermittent welding.
- (4) After finishing the welding the robot returns automatically to the indicated position.

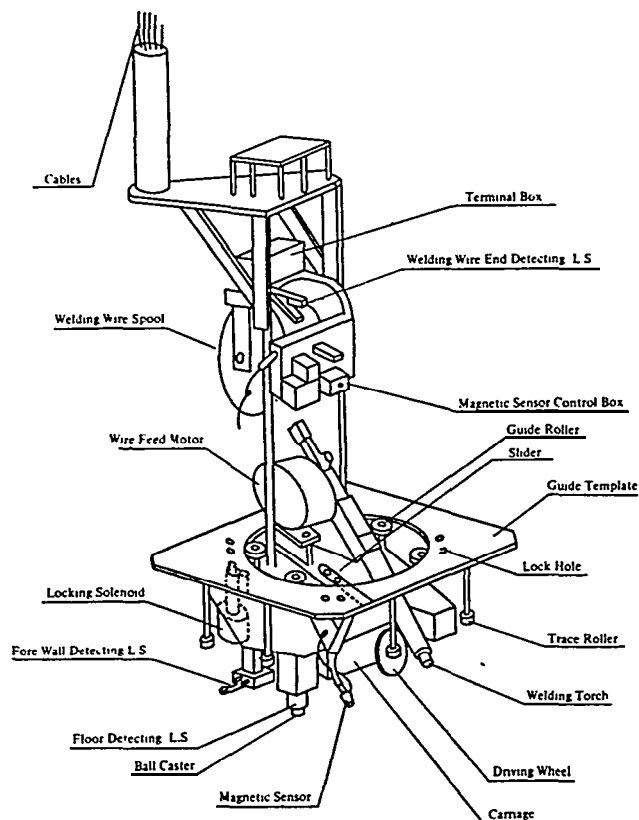


Fig. 2 Schematic figure of lattice horizontal fillet welding robot machine

## 2.2 Construction of Welding Robot

The construction of the welding robot's body is shown in Fig. 2.

The carriage is supported by driving wheels and casters, and the guiding plate is attached so as to rotate by the guide roller fixed to the carriage. On each side of the guiding plate are mounted four rollers that follow the vertical plate. The guiding plate and the carriage are locked, when running straight, by the locking hole in the solenoid for locking and the guiding plate. The driving wheels always follow the walls. All these combined prevents the vibration of the carriage.

On the upper surface of the carriage, is attached a slider with a magnetic sensor which detects the non-welded part and the welding torch can move forward and backward to enable the magnetic sensor and the welding torch to move along the groove under the guiding plate, when rotating. Thus the slider can guide the sensor and the torch without changing the aiming point at the corner.

### 2.2.1. Rotation Mechanism

#### (1) Rotating movement

The robot rotates when reaches to the end part of straight line by catching information that the fore wall detecting limit switch touches the next vertical plate (a frame or web). Rotating movement is done by the release of lock and the reversal of driving wheel.

#### (2) Shape of guide groove for welding torch

The magnetic sensor and welding torch slide on the sliders being guided along the guide groove which is equipped under surface of the guide template in order to keep the constant distance from the welding torch to the vertical plate when rotating movement at the corner parts.

The shape of this groove is calculated by equation (1) and shown on Figure 3.

$$r = \frac{R}{\cos \theta} - \ell \quad \dots\dots\dots (1)$$

where:

- R: Distance from center of guide template to wire aiming position (constant)
- $\ell$ : Distance from wire aiming position to center of guide groove (constant)
- r: Distance from center of guide groove to center of guide template

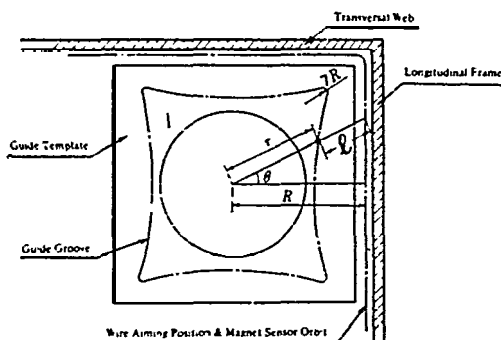


Fig. 3 Shape of weking torch guiding groove

At the place where  $\theta$  is 45 degrees, the groove is, however, rounded with 7 mm radius in order to smoothen the movement of the torch and to escape from already welded vertical bead.

### 2.2.2 Speed control at corner part

The speed of the wire aiming position of the torch must be kept constant at the straight line part and the corner part as well. The static Leonard controls the driving wheel speed with 7 kinds of speed control signals in order to keep the speed within  $\pm 2.5\%$  deviation.

### 2.2.3. Control of non-welded part

In order to weld automatically the four sides of a rectangle by the robot, it must be performed intermittent welding at the non-welded parts. The difficult problem of the intermittent welding is as follows. That is, even if the sensor detects the welding stop point, the torch must continue welding until the time when the torch reaches the real welding stop point, and similarly even if the sensor detects the welding start point, the torch must not start welding until the torch reaches the real welding start point;

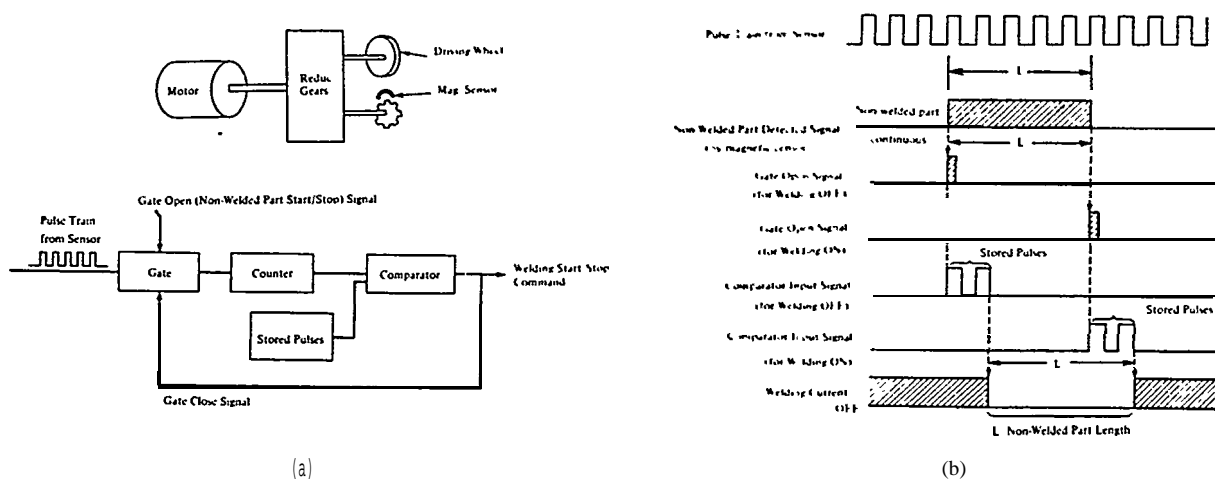


Fig. 4 Control of non-welded part

We solved this problem on the robot by applying electric pulses which are converted from the driving wheel rotation. Figure 4 (a) shows the mechanical elements for this conversion. The pulse generating gear is connected to the driving wheel through the reducing gears with a fixed gear ratio. A magnetic sensor in front of the gear generates pulses of which the number is proportional to the number of passing teeth, i.e., to moving distance of the carriage. So the pulse train is being continuously generated during carriage movement. Fig. 4 (b) shows the control of non-welded parts.

### 3. WELDING SYSTEM

For the practical use of the welding robot, it is required that one man (or two) can handle many machines from the point of efficiency. So far in this kind of handling, an operator sets and handles the welding machines one by one, in which case he has only a limited number of machines to handle. To overcome this, a system has been developed wherein many robots can be operated at the same time.

In other words, in this system, many welding robots are simultaneously thrown into each lattice, and thereafter, one operator can handle operation from welding on circuit of a lattice to the movement to the next lattice after finishing welding. This system consists of welding robots, the concentrated control box and the handling apparatus.

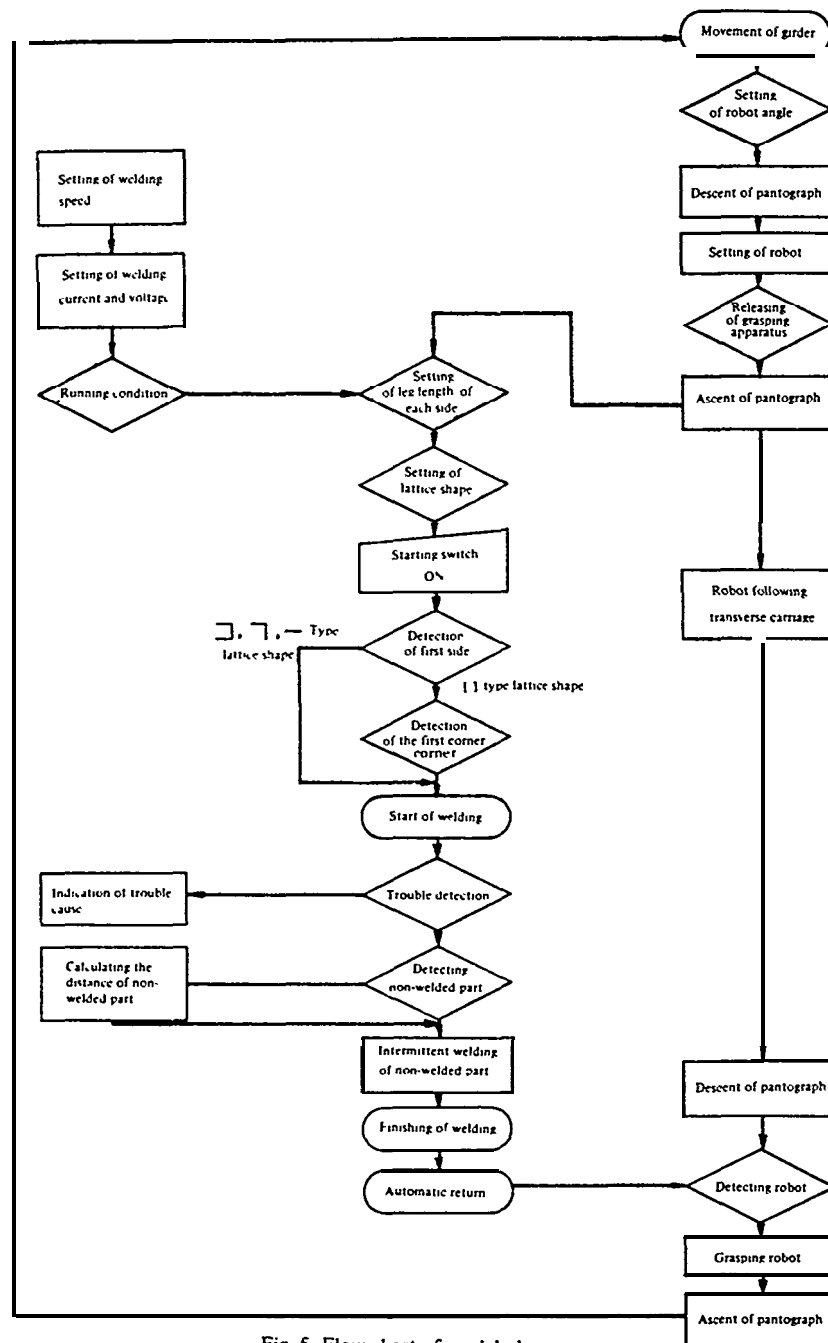


Fig. 5 Flow chart of model plant

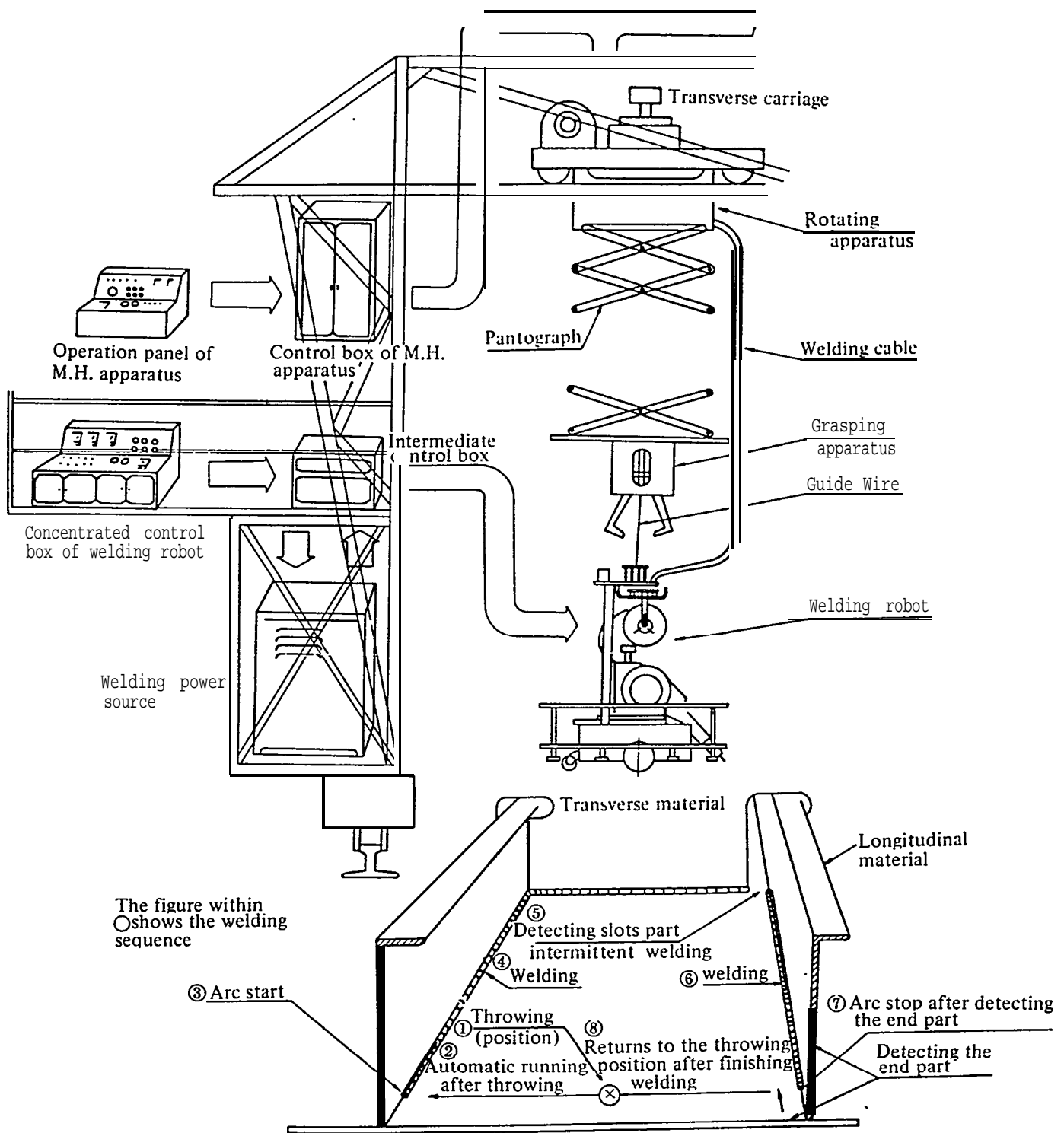


Fig. 6 Explanation of welding system of model plant

Fig. 5 and Fig. 6 show their rough sketches and the flow chart of the welding system. A model plant of this welding system is shown in Photo 1.

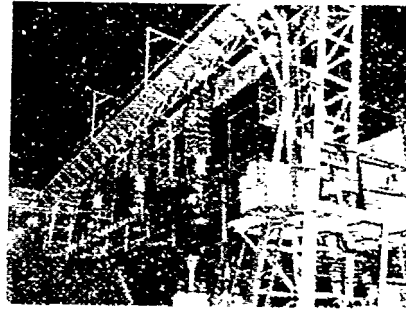


Photo 1 Appearance of model plant

#### 4. WELDING APPLICATION FOR ACTUAL SHIP

##### 4.1. Welding Procedure Conditions for Application to Actual Ship

Photo 2 shows application of the model plant to a panel block of a 150,000DWT tanker. Table 4 shows the procedure conditions of the robot, and table 5 shows the application standard of hull construction.



Photo 2 Application for panel block

Table 4 Procedure condition of welding robot

Shielding gas:	80% Ar + 20 % CO <sub>2</sub>
Wire reforming:	With two rollers
Torch inclination:	43.5 degrees
Torch advance:	11 degrees
Wire aiming position:	3.5 mm
Welding condition with 2.0 mm dia wire	
8 mm leg length:	450A, 35V, 300-350 mm/min.
6 mm leg length:	450A, 35V, 400-470 mm/min.

Table 2 5 Application standard of hull construction

Item	Range of application
Slab longi. frame height	more than 60 mm
Build-up longi. frame height	more than 250 mm
Longi. frame face width	less than 120 mm (welding side of frame)
Drain hole width	less than 150 mm
Slot width	less than 185 mm
Robot carrying-in passage	more than 520 x 520 mm

##### 4.2. Procedure Result

Horizontal fillet welding depends on accuracy of parts to be welded. Generally speaking, welding speed must be reduced to obtain the same leg length when increase of welding gap width, and non-perpendicularity of two plates to be welded will bring unsymmetry leg length and under-cut due to change of welding wire aiming position. Fig. 7 shows the results of tests about relations among welding speed, leg length and gap.

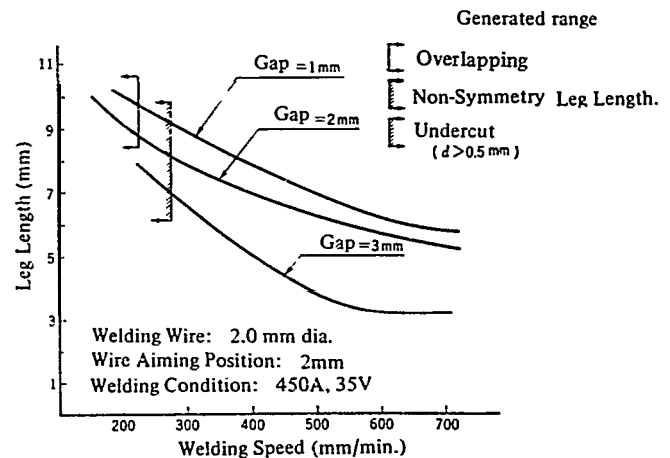


Fig. 7 Relation between welding speed and leg length

### 4.3 Estimating Effect

(1) The utilization factor of the robots was 65% at the application by the model plant. Fig. 10 shows efficiencies of various horizontal fillet welding devices used in most of the Japanese shipyards and of this robot with the value of 50% utilization factor.

The robot will contribute to improvement of welding efficiency with simultaneous operation of 10 - 20 robots and full automation of horizontal fillet welding of lattices.

(2) Repairings are reduced by 50 percent of gravity welding.

(3) Leftover of weld which is inevitable in gravity welding or fine wire submerged arc welding (usually about 10 percent of the total weld line) is eliminated.

(4) No skilled operator is needed and allows a single operator to take charge of plural welding machines.

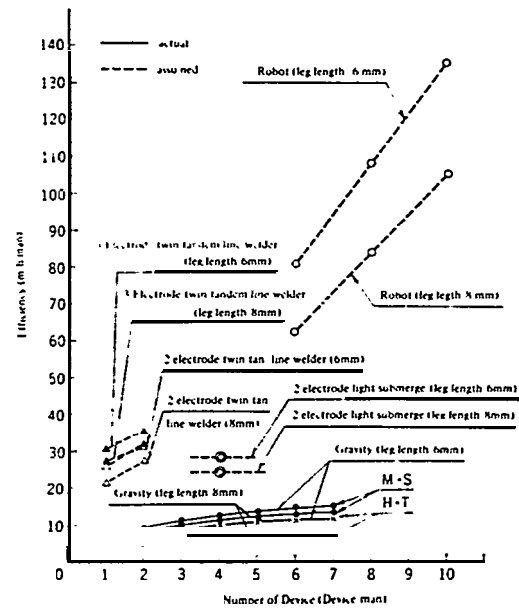


Fig. 10 Comparison of efficiency between various horizontal fillet welding machines

PART II

Automatic Hull Subassembly Machine



An automatic subassembly machine devised by the M.H.I. automatically lifts, hauls, positions, and tack welds stiffening members to a conveyor-transported web plate to fabricate a deck, side, or bottom transverse of the ship web frame. Now in operation in the Koyagi Shipyard of Mitsubishi Nagasaki Shipyard and Engine Works, the automatic subassembling machine has proved a great success, raising the production efficiency and morale of workers in the subassembly process. Further improvements are being made to the method of regular welding of stiffening members.

## 1. INTRODUCTION

Web frames in the cargo tanks of oil tankers consist of deck, side, and bottom transverses and constitute very important hull structural members. Placed at intervals of about five metres in the longitudinal direction, the web frames strengthen the ship hull transversely at the deck, side, and bottom. The deck, side, and bottom transverses are each made up, principally, of a web plate and a face plate and reinforced with stiffeners, brackets, etc. The process of fabricating these transverses is called the subassembly process, which may be generalized as consisting of:

- (1) Positioning and fitting up web plates
- (2) Joining the web plates by butt welding
- (3) positioning and tack welding stiffeners and brackets to the web plate
- (4) Positioning and tack welding the face plate to the web plate
- (5) Regular welding of the stiffeners, brackets, and face plate to the web plate to form a transverse
- (6) Turn-over of the transverse
- (7) Positioning and welding piece parts to the reverse side of the transverse.
- (8) Transportation of the completed transverse to the next assembly process.

Hauling, positioning, and welding in the subassembly process has traditionally relied mostly on physical labour, assisted by lifting cranes. With the advent of very large oil tankers, however, even one transverse fabricated in the subassembly process now measures about 25-30m in length and 5-8m in width and weighs as much as 25-30 tons. Stiffening members fitted to such a transverse are also very large, with some brackets weighing almost a ton a piece. All this makes the manual handling of transverse components difficult and hazardous. This being so, the weight

of transverses fabricated amounts to about 7000 tons in total per ship. Improvement of production efficiency is therefore as important a consideration as the safety of work. Also, a great amount of welding fume produced in the subassembly process demands serious attention. Accordingly, vigorous efforts have been made by the shipbuilding industry to find solutions to all these problems. The results of the efforts are improvements of production facilities and methods of fabrication, such as extensive use of the conveyor system, welding by the onesided submerged-arc process, mechanised or automated handling of stiffening members and face plates, adoption of the submerged-arc fillet welding process specifically to reduce the welding fume, etc. Of these improvements, the most worthy of note is the development of subassembling machines which automatically position and tack weld stiffening members to the web plate. In fact, the subassembling machines have broken the bottleneck created by limitations of the crane-assisted manual handling of transverse components. This Paper concerns an automatic subassembling machine which, is now in successful operation in the Koyagi Shipyard of Mitsubishi Nagasaki Shipyard and Engine Works.

## 2. OUTLINE OF MITSUBISHI'S AUTOMATIC SUBASSEMBLING MACHINE

### 2.1 Basic design concept

The basic design concept adopted in devising the automatic sub-assembling machine included:

- (1) The machine would be stationary while the web plate would be fed into the machine by a powered roller conveyor.
- (2) The machine would be designed to be capable of handling, principally, the large number of stiffening members which were located at right angles to the edge of the web plate; those which were slanted in relation to the edge of the web plate would be fitted along with the face plate in the subsequent subassembly stage.
- (3) The machine would be designed to complete an operational cycle in 2 min, having due regard to the optimum work load to be handled in the subsequent subassembly stage and also to the total amount of production to be achieved in the subassembly process as a whole.

- (4) The machine would be equipped with platehandling magnets to lift, haul, position, and hold a stiffening member on the web plate. The magnets would be capable of exerting a force of attraction 3-10 times as great as the weight of the stiffening member to be handled, and would serve as permanent magnets in the event of power failure to prevent the stiffening member from dropping. Also, the current in the magnets would be reversible for the efficient release of the stiffening member from the magnets. The magnets to lift and haul the stiffening member would be fitted to a part carrier, which would be designed to travel on a pair of bridge girders at a speed of 20 m/min to lessen the momentum of the carrier motion at the start and stop, with this carrier travel time being made compatible with the cycle time of the machine operation.
- (5) The machine would have a set of welding heads of the type which deposit welds using the fillet of the stiffening member and web plate as a guide.
- (6) The machine would be designed to be capable of a full automatic operation except for the minimum manual attention of depressing start and tack weld push buttons. However, to spare the machine operator the monotony of work, the machine would intentionally be made to leave some room for manual attention, such as a slight manual adjustment before the start of tack welding and also the manual tack welding from one side.

## 2.2 Construction

The automatic subassembling machine consists of the following principal components, as shown in Fig. 1.

Sliding part rack

Part carrier with an extendable head equipped with a set of circular plate handling magnets

Pair of bridge girders with carrier tracks on them

Part holder equipped with a set of circular plate-holding magnets

Numerical-controlled part positioner

Slot-sensing photoelectric tube

Set of bottom plate-holding magnets

Set of automatic welding heads for tack welding

### 2.3 Principle of machine operation

Operation of the automatic subassembling machine and that of the powered roller conveyor are completely coordinated. Stiffening members are placed on the sliding part rack in prearranged order. The web plate is fed into the automatic subassembling machine by the rollerconveyor, and the photoelectric tube built into the machine senses the presence of a slot for the longitudinal in the web plate to halt the roller conveyor. The part carrier picks up a stiffening member from the part rack and travels on the bridge girder to haul the stiffening member until it stops above the web plate at the right position where the stiffening member is to be lowered for tack welding. The carrier head then descends with the stiffening member to the level of the part holder until the stiffening member becomes sandwiched between the carrier head and part holder which are designed to close the distance in between, allowing a minimum of necessary free play for the stiffening member to move axially. Power for the part-carrier magnets is then cut off to permit the stiffening member to drop under its own weight on to the web plate. Though the stiffening member as dropped on to the web plate still remains sandwiched between the carrier head and part holder and is therefore accurately positioned, the numerical-controlled part positioner finally adjusts the distance between the end of the stiffening member and the edge of the web plate. The part-holder magnets and bottom plate-holding magnets are then energised to hold the stiffening member firmly in place for tack welding, and the carrier head ascends and the part carrier retreats. The stiffening member is tack welded to the web plate by the CO<sub>2</sub> gas-shielded-arc process. With the stiffening member tack welded and released from the hold of the part-holder and bottom plate-holding magnets, the web plate is moved forward by the roller conveyor until the photoelectric tube senses the presence of the next slot in the web plate. All these operations are carried out automatically except for the manipulation of the start and tack weld push buttons on the control console.

### 3. WORK IMPROVEMENTS ACHIEVED BY USE OF THE AUTOMATIC SUBASSEMBLING MACHINE

#### 3.1 Improvement of productivity

As a result of the use of the automatic subassembling machine, eight platers are now required to handle and tack weld to the web plate the stiffening members and face plate as against thirteen who used to work full time to do the same job, while the amount of production per month of transverses increased to 4000 tons from 1600 tons in steel weight. In terms of length, transverses produced per day increased to 220 m from 90 m, or to 28 m from 7 m per plater per day.

#### 3.2 Improvement of work accuracy

Since longitudinals are to be passed through the transverse by way of slots in its web plate, the distance between the end of each stiffening member and the edge of the web plate should be accurately controlled to the specified value in tack welding. As can be seen from Fig. 2, the accuracy of the positions of the tack welded stiffening members in relation to the edge of the web plate was improved to  $\pm 2$  mm by use of the automatic subassembling machine, as against the -3 to + 4 mm formerly obtained by manual work.

### 4. CONSIDERATIONS AND FUTURE IMPROVEMENTS

- (1) As compared with the traditional method of fabrication in which stiffening members were lifted, positioned, and tack welded one by one to web plates manually with the aid of an overhead travelling crane etc., the use of the automatic subassembling machine greatly increases the efficiency, accuracy, and safety of shop work.
- (2) Installed about two years ago, the automatic subassembling machine has since been in operation without any particular difficulty, which bears witness to its high reliability.
- (3) Though the existing automatic subassembling machine is somewhat limited in its motion, being able to tack weld the stiffening member only at right angles to the edge of the web plate, the second machine now under development is designed to be capable of rotary motion so that the stiffening member can be tack welded at various angles to the edge of the web plate.

- (4) As part of the improvement of the subassembly process by use of the automatic subassembling machine, it is considered necessary to use the submerged-arc fillet welding machine instead of the existing gravity welding machine for regular welding of stiffening members and face plates to the web plate to reduce the amount of welding fume. The submerged arc fillet welding machine produces far less fume than the gravity welding machine but offers little gain in efficiency. As a solution to this problem a device which automatically controls the operation of the welding head of the submerged-arc fillet welding machine has been developed. Shown in Photo. 2, the submerged-arc fillet welding machine with this control device has already been successfully tested in the shop.
- (5) Where the floor space is a limiting factor a combination of one subassembling machine and two conveyor lines will be possible to ensure the capacity operation of the machine. The arrangement will also offer the advantage of being able to position and tack weld stiffening members to a web plate whether the web plate has slots on its right or left side in relation to the machine.

## 5. CONCLUSION

The use of such a new subassembling machine and welding machine does not automatically lead to improved production in the subassembly process. Shop workers who operate these machines are an important factor to consider. The psychological effects of the machines on shop workers were, therefore, carefully weighed, and platers and welders were encouraged to participate in the development of the machines from the beginning. Also, the necessary training was provided for them to become familiar with the machines. It is believed that all this made for the successful application of the automatic subassembling machine in the subassembly process.

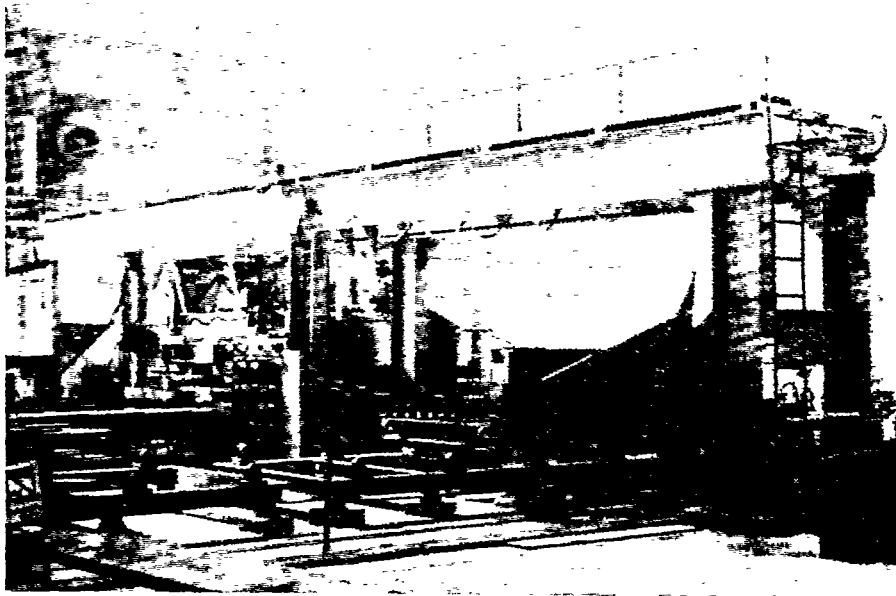


Photo. 1    General view of the machine

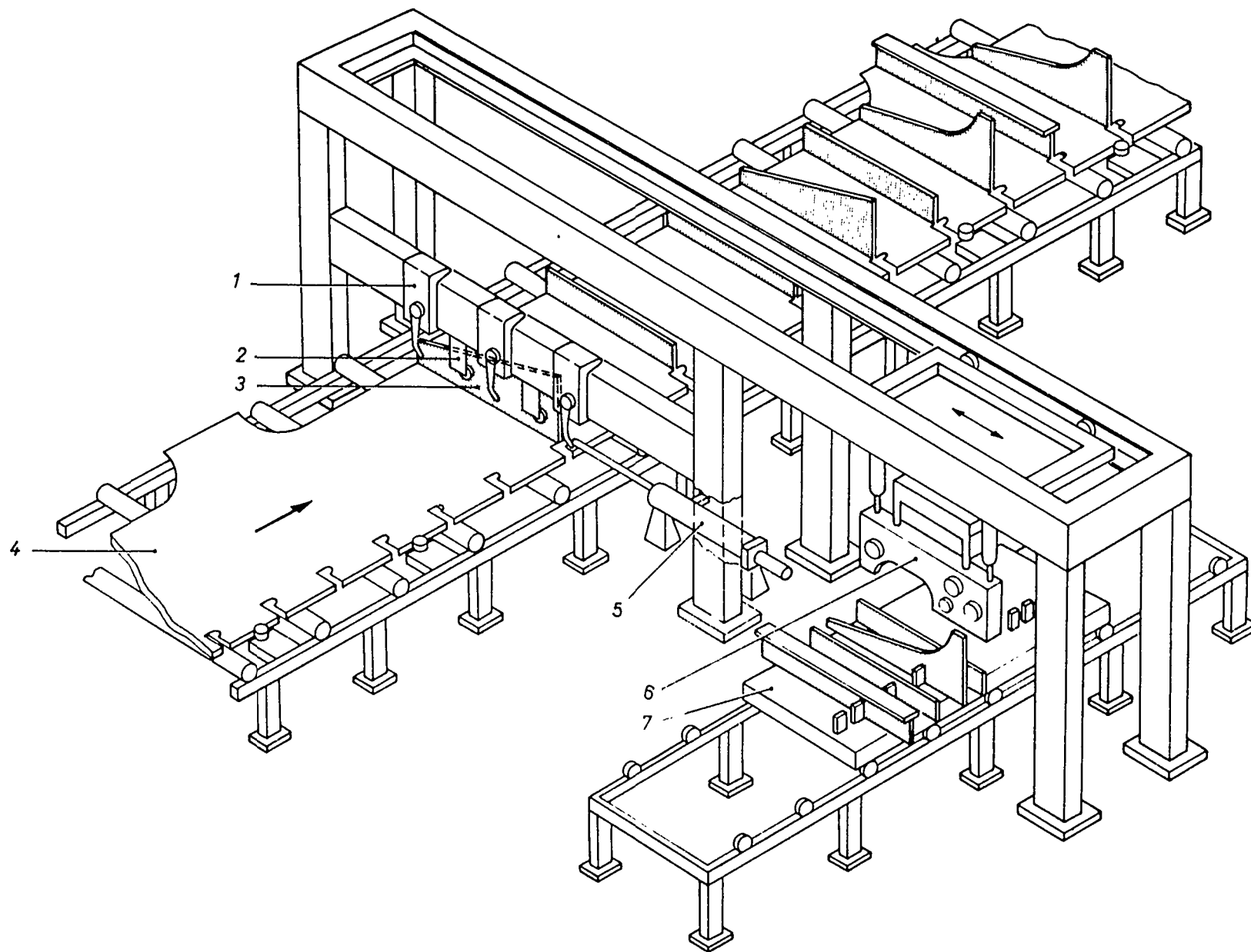


Fig. 1 Construction of automatic subassembling machine. 1—welding head; 2—part holder; 3—bracket underfitting; 4—web plate; 5—part positioner; 6—part carrier; 7—sliding part rack



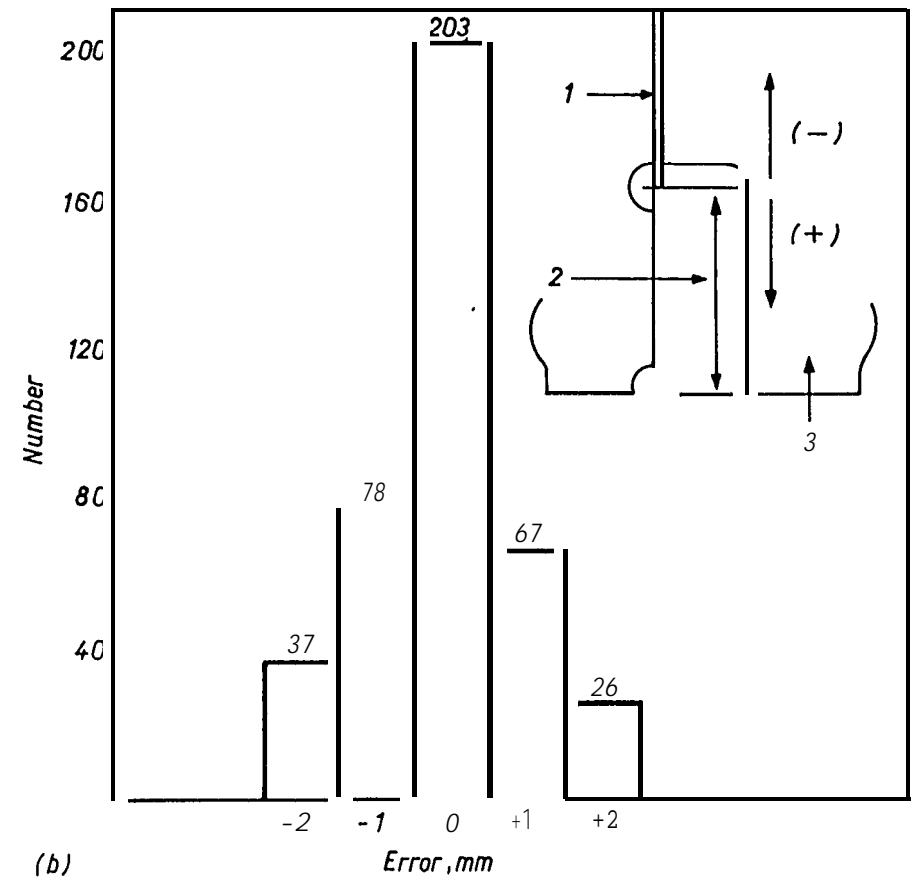
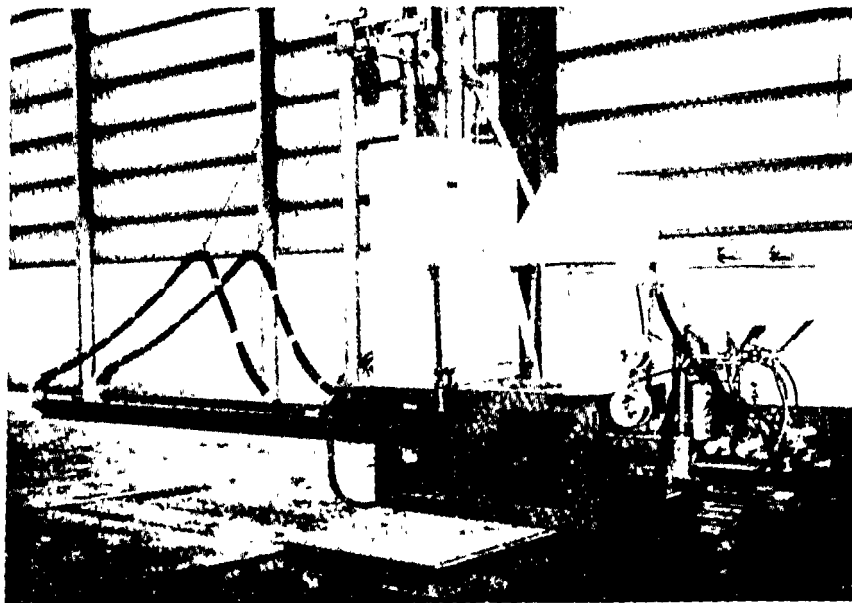
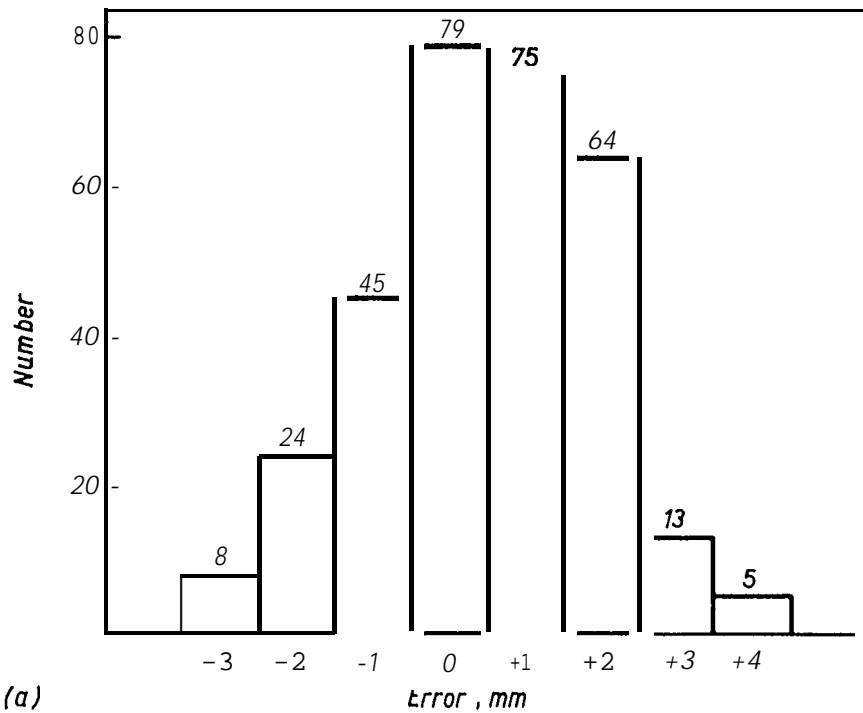


Fig. 2

Comparison of accuracies with which stiffening members are fitted: (a) manually:  $N=313$ ;  $\bar{x}=+0.463$ ;  $\sigma=1.467$ , (b) mechanically:  $N=411$ ;  $\bar{x}=-0.08$ ;  $\sigma=0.98$ .  
1—bracket stiffener; 2—specified distance; 3—web plate

Photo . 2

Submerged-arc fillet welding machine with automatic control device

### PART III

#### Centrally Controlled Pipe Processing System

## 1. OUTLINE :

This system centrally controls as well as automates various phases such as fabrication, assembly and handling of small and medium-sized straight pipes in pipe shops.

Pipes to be fabricated are taken out of pipe racks where pipes of various kinds are stored, and cut into required lengths. After selection of the required flanges from flange racks, positions of the bolt holes in the flanges are adjusted, and then the pipes and flanges are tack-welded, prior to permanent welding. When finishing work on the flange surfaces has been completed, the pipes to be bent are separated from the others. The system includes a minicomputer which centrally controls as well as provides operational information inputs, to individual controllers which function solely for their corresponding individual processing machines. The latter perform their functions in accordance with instructions transmitted from their respective controllers. Incidentally, each processing machine has an input function of its own as backup, so that it is capable of handling unscheduled pipes which are not registered on the input tape of the system.

## 2. FEATURES :

- 1) Conventional method required about 9 workers for these works.  
With this system 3 workers will be able to carry out these works.  
Since all phases of work are fully automated, special skill or judgement on the operator, indispensable in conventional manual processing methods, is not necessary.
- 2) This system can stock processing pipes in spaces between processing machines and greatly improve efficiency with parallel operation of the machines.
- 3) Designed average processing time for one piece is approximately 3 min.

Note: This machine is now on test trial.

### 3. SYSTEM CONFIGURATION :

The system is a fully automated line regulated by a concentrated control unit to perform all phases of operation from taking out of the piping materials, cutting, flange installation, and all the way through to completion.

----- Note: The scope of the equipment is within this line.

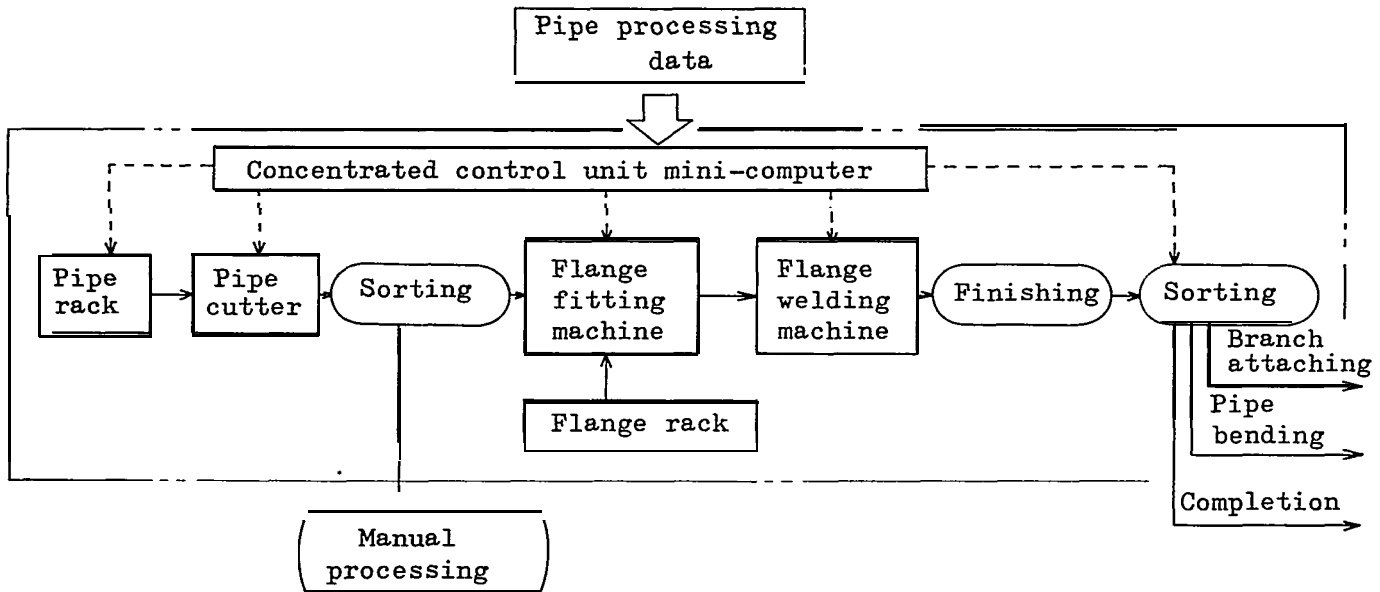


Fig. 1. Flow chart of the system

Following picture shows the layout of machines and devices included in this system.

Practically, the layout should be completed in consideration of all factors concerning pipe shop.

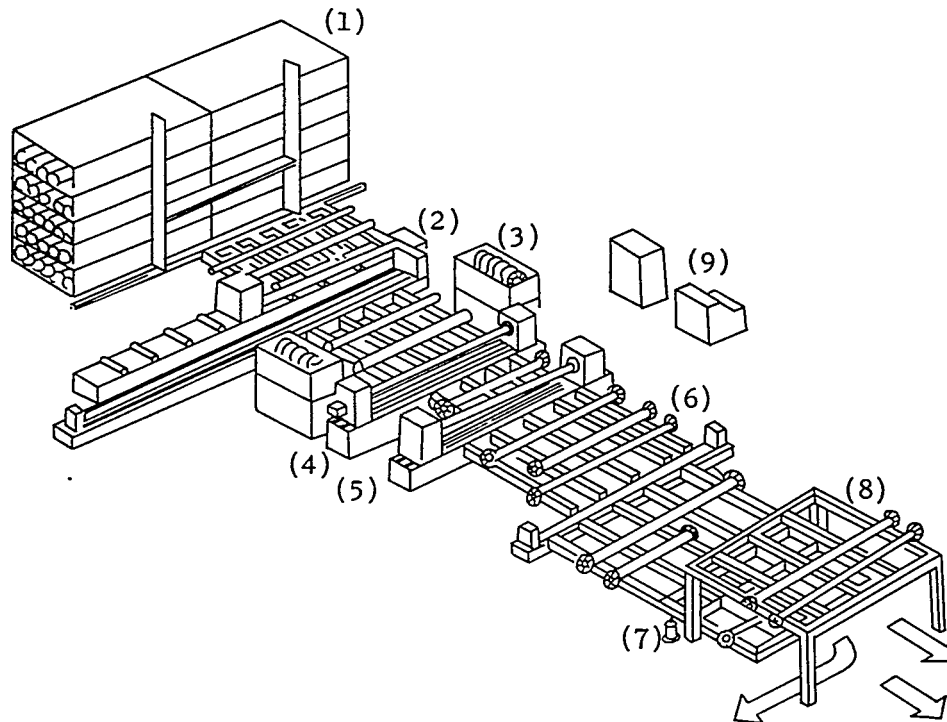


Fig.2 Bird's-eye view of the system

- |                            |                            |                 |
|----------------------------|----------------------------|-----------------|
| (1) Pipe racks             | (2) Pipe cutter            | (3) Flange rack |
| (4) Flange fitting machine | (5) Flange welding machine |                 |
| (6) Flange finishing table | (7) Pipe sorting device    |                 |
| (8) Pipe skids             | (9) Control console        |                 |

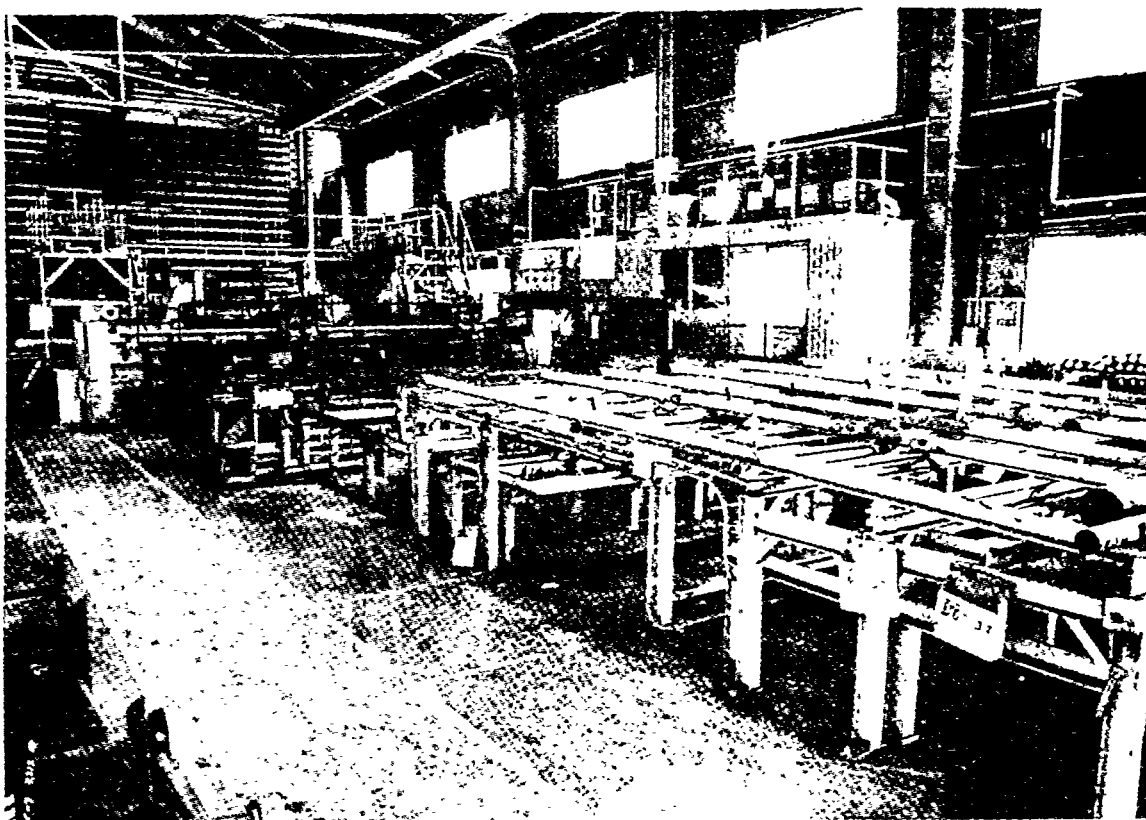


Photo 1. General view of the system

## PARTICULARS

### Pipe rack

Rack	2 rows x 17 levels
Pipe loader and unloader	each 1 set

### Pipe cutter

(1) Nominal diameter of the pipe possible to be cut	40 - 200mm
(2) Wall thickness possible to be cut	1.5 - 30mm
(3) wall thickness possible to be subjected to bevel preparation	4.5 - 15mm
(4) Length of the original pipe	2,000 - 5,500mm

### Flange fitting machine

In accordance with the instruction from the central processing unit, the machine automatically receives the pipes and flanges, inserts the pipe into the flange and performs tack - welding.

#### (1) Processed steel pipe

Nominal diameter	40 - 200mm
Length	1,500 - 5,500mm
Wall thickness	3.5 - 12.7mm

#### (2) Flange

Nominal pressure	5 kg/cm <sup>2</sup> , 10 kg/cm <sup>2</sup> , 16 kg/cm <sup>2</sup>
------------------	--

### Flange welding machine

By means of the central processing unit, flanges are welded both internal and external surfaces at the same time.

Pipe and flange possible to be welded are same in case of Flange fitting machine.

### Pipe sorting device

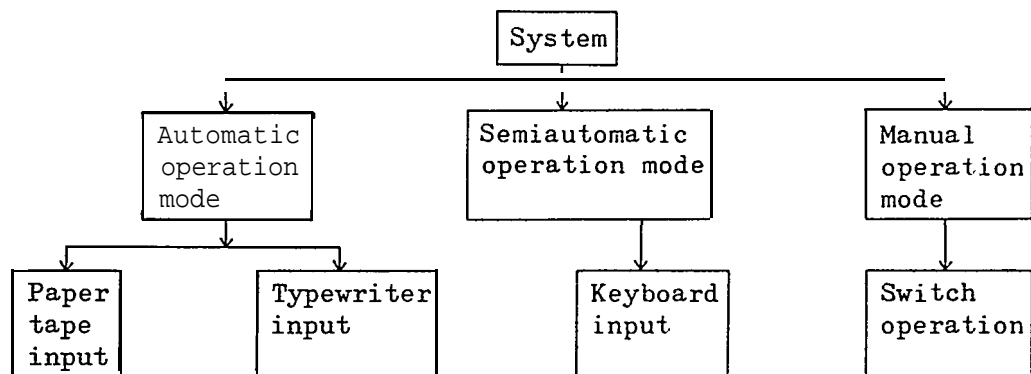
At the final sorting stage in way of pipe skids, air cylinders are provided for lifting of skid and operation of gate.

### Central control unit

Mini - computer	1 set
Memory capacity	12 kW
One word length	16 bits

## 5. OPERATION CONTROL

### 5.1 Composition of Operation Control Modes



#### (1) Automatic Operation with Paper Tape Input

Automatic operation with N/C tape which is generated as shown in Fig. 3 is the basic operations mode of this system.

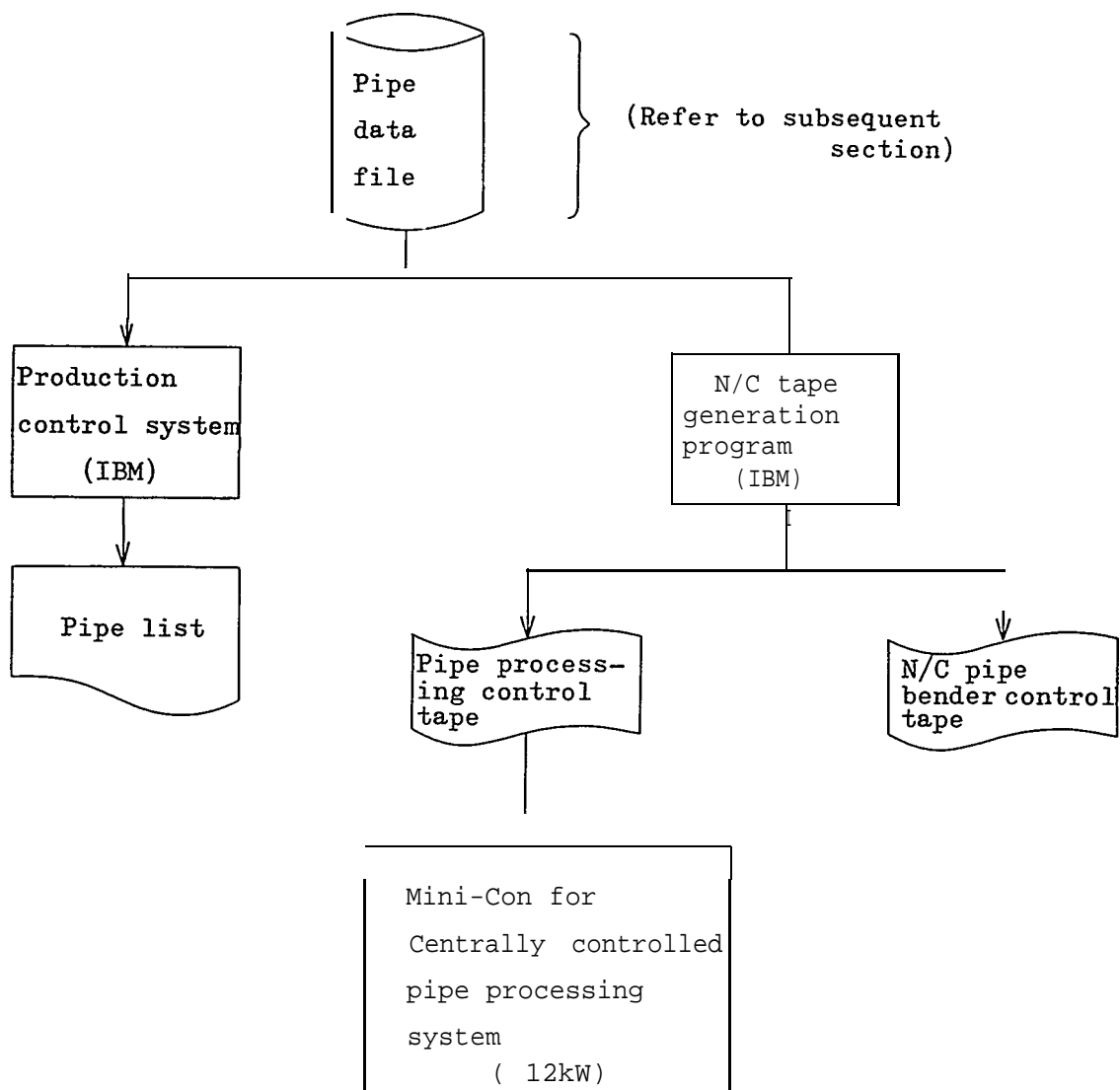


Fig. 3 N/C tape generation flow



If any one unit of equipment is switched over to the manual or semiautomatic operation mode during on-line operation, all subsequent units are released from the automatic operation mode.

(2) Automatic Operation with Typewriter Input

When the automatic operation mode is in effect, interrupt automatic operation with typewriter input is possible with respect to an unscheduled pipe requiring urgent processing.

Interruption is possible in the following two positions:

Case 1 - Pipe buffer before the cutter

Case 2 - Pipe feeder after the cutter

To enter interrupt information, the pipe rack system in Case 1, or the pipe feeder in Case 2, is temporarily suspended from operation. Input data should cover all information from the pipe rack data on in Case 1 or from the flange fitting machine on in Case 2.

(3) Semiautomatic Operation with Keyboard Input

This mode is used for processing of pipes remaining on the store rack after a trouble. Semiautomatic operation with keyboard input differs from automatic operation with typewriter input in that the former can enter only the data regarding the unit of equipment involved.

(4) Manual Operation

The manual operation mode permits separate regulation of each control axis by switching. It is usually applied only for maintenance or for recovery after a trouble.

## 5.2 Input, Data Format (in the automatic operation mode)

The input code is ASCII-CODE

JN( )-( ) SN( )-( ) RT

CL( ) SPO DM( )

CTEOGO\*

TWK( )H( )FO\*

### (1) Pipe Fabrication Number

JN ( ) - ( )  
 ↑        ↑  
 Date    Serial number

### (2) Sequence Number

SN ( )-( ) / ( )  
 ↑        ↑        ↑  
 Serial number of the unit    Subnumber of the unit    Refers to a unit of pipe material

### (3) Route of Conveyance

RT ( )  
 Indicates whether plated or not branched or not, etc.

### (4) Cut Length of Pipe

CL( )  
 Cut length (in millimeters)

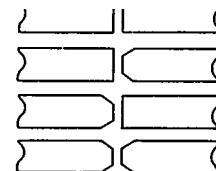
### (5) Pipe Material

### (6) Pipe Diameter

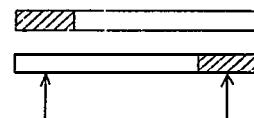
DM ( )  
 Eight different diameters, 40, 50, 65, 80, 100, 125, 150  
 and 200 mm

### (7) C T E O G O

E 0        Cut squarely  
 E 1        Bevel cut at fore end  
 E 2        "        back end  
 E 3        "        both ends



G O  
 G 1        Remaining part control  
 G 2        Forwarding part control



↑        ↑  
 to be used    to be scrapped

(8) Flange Welding Data

TWK OO H  $\pm$  OO F O

K o o	Kind of flange (in terms of nominal pressure)
H $\pm$ OO	Rotating angle of flange bolt hole
F O	Indicates presence or absence of flange
F 0	Unflanged
F 1	Flanged at one end, welded
F 2	Flanged at both ends, welded
F 3	Flanged at one end, tack welded only
F 4	Flanged at both ends, tack welded only
F 5	Flanged at both ends, welded at one end, the other end tack welded only

## 6. PS/36 (N/C DATA GENERATION SYSTEM)

### 6.1 Outline

PS/36 is an integrated system extending from design to production stage for pipe outfitting, and is an important tool for rationalization of outfitting work. In this system appropriate pipes and valves are selected by feeding piping data picked up from detail pipe arrangement plan and the piping data are checked and corrected in reference to fabrication criteria. then piece drawing of pipe is obtained.

### 6.2 Features

- (1) Increase of accuracy and efficiency of fabrication and assembly work.
- (2) Saving of man-power and time of piping design.
- (3) Reliable results even by unskilled workers.
- (4) Capable of connection with production control system for outfitting work, as well as with N/C pipe fabrication system.
- (5) Easy input by designer-oriented PIPE language.
- (6) Easy expansion and modification of system by its modular configuration.
- (7) Reduction of input load by a number of standard files including fabrication practice and particulars of pipes, valves, etc.

### 6.3 System Configuration

- (1) Language processor  
Translating input piping data coded with pipe language, and breaking-down into a series of pipe piece data (to be stored into data base).
- (2) Standard file maintenance program  
Storing 'fabrication practice, particulars and patterns of pipes, valves, etc.
- (3) Drawing program  
Drawing pipe lines in various forms such as projection, profile and birds-eye-view.
- (4) Pipe piece drawing program  
Output of pipe lists and piece drawings.

This system can be easily connected with other systems such as production control and N/C fabrication systems through data base and can be operated on IBM/370, UNIVAC 1100, and CDC 6400 at present.

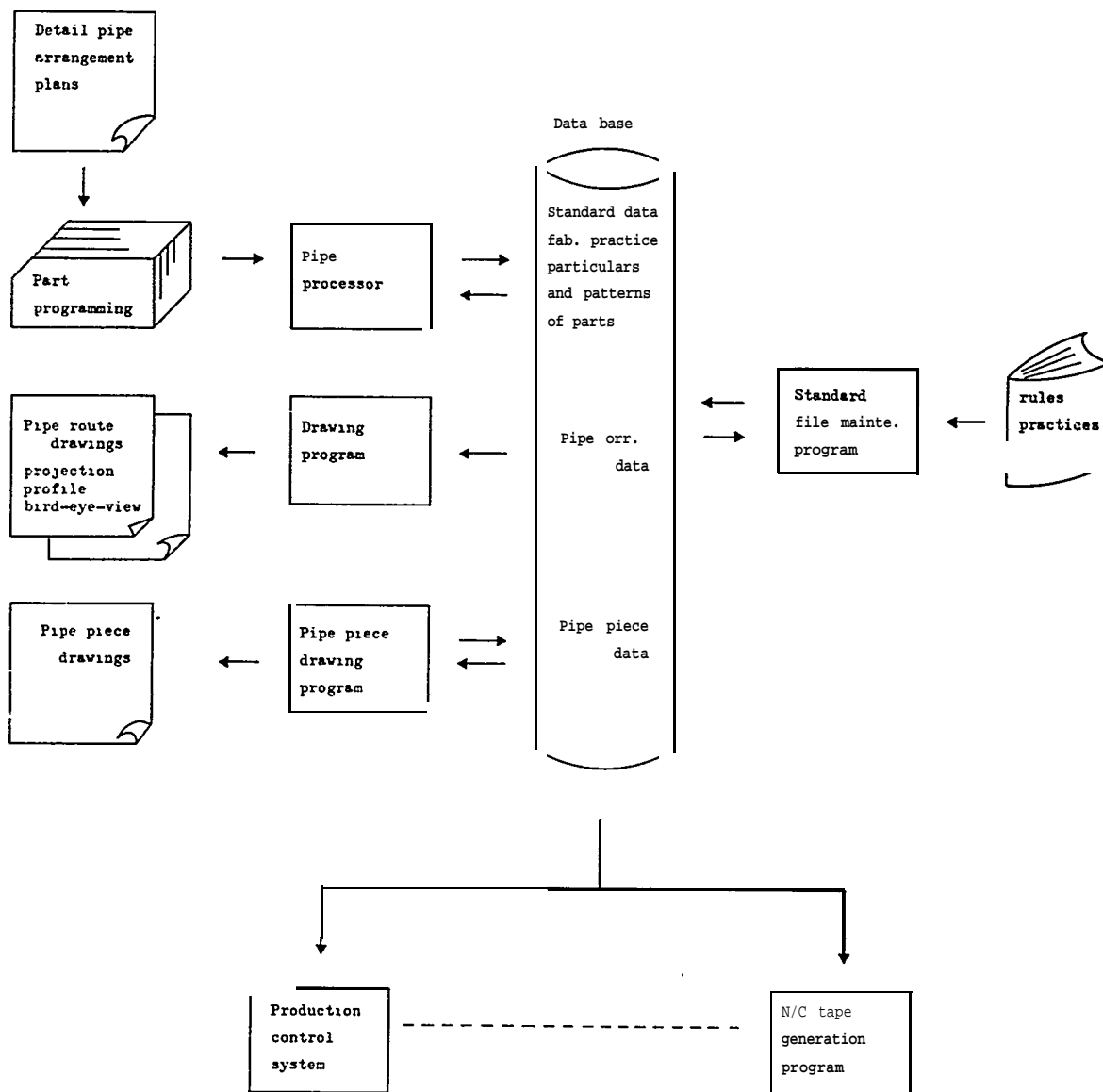


Fig. 4 N/C Data generation system configuration

## USE OF PRELIKON AT ZIGLER SHIPYARDS

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## ABSTRACT

The objective of this paper is to demonstrate to its readers that it is possible for a shipyard, the size of Zigler, to maintain a small but an effective engineering group provided it is supported by a powerful tool like PRELIKON. Further, an inhouse engineering department in a shipyard reduces communication gaps between engineering and production, thus giving rise to increased productivity.

## INTRODUCTION

The advent of computers is having and will continue to have a profound effect on the practice of Naval Architecture and the Art of Shipbuilding. The introduction of computers in general, as an aid to ship design in particular, has been widely accepted by the profession particularly in its simplest mode, as a sophisticated tool to perform routine tasks of a repetitive nature. Such applications are generally of immediate economic return, as they allow substantial reduction in manhours together with greater accuracy and thoroughness. Professor Horst Nowacki, in his paper, "Modern Approach to Integrated Ship Design," says, "The aspect of ship production must be treated as an integral part of ship design. The effects of production methods, time, and cost upon design decisions must be taken into careful consideration from the earliest design stage on. No artificial barriers must be permitted to exist between design and production decisions." I fully agree with Professor Nowacki's statement, and further believe, that this statement can be most effectively realized if the ship built by the shipyard is designed by its people too. At Zigler Shipyard, we do the complete design and engineering from the owner's requirements, with the aid of integrated computer programs called PRELIKON.



## DISCUSSION

### The Shipyard and Its Capabilities.

Zigler Shipyard, Division of Lee-Vac, Ltd. is situated on an 83 acre tract off the Mermentau River in Jennings, Louisiana. The shipyard was founded in 1913 for shipbuilding and repair as a Division of the G. B. Zigler Company, and started off building wooden barges. In 1967, the name of G. B. Zigler Company changed to Zigler Shipyard. Today, Zigler continues its knowledge and skills gained throughout its long period of operation with its commitment to utilize modern technology in its multi-phased construction efforts. Computer applications in the area of planning, scheduling, warehouse and material control, budgeting, and recently in the field of engineering, have contributed immensely to streamlining and making the shipyard more efficient-

The shipyard employs about 300 persons who build and repair barges, tugs, towboats, menhaden vessels, offshore supply vessels and seismographic vessels. Three years ago, the yard was building simple 150 ft. supply vessels for the Gulf of Mexico at the rate of three to four boats per year. Today, we are designing and building over 210 ft. offshore tug/supply vessels for North Sea operations, and delivering them at the rate of six to eight ships per year.

The Necessity For a System Such as PRELIKON.

Just a few years ago, the supply vessels that were built in the Gulf Coast Shipyards were small and simple, and were built mainly for use in the Gulf of Mexico. The owners of these vessels were easy to please, and there was plenty of work waiting for this new breed of vessels. The contract specifications for these vessels were thin, and the owners were happy as long as the overall dimensions of the vessel conformed to the specifications. As the supply vessels increased in number, the competition for work grew more keen. This prompted the owners and the operators to think *in* terms of required freight rate, and therefore, cargo deadweight.

The severe competition in the supply vessel business made the owners more demanding in the cargo carrying capacity, and the general performance of the vessel. Several owners and operators hired Naval Architects and Marine Engineers to write the specifications and act as owner's representatives. This transformed the contract specifications which formerly consisted of a few pages into a bound volume, with guarantees on deadweight, minimum deck cargo capacity, fuel capacity, speed and bollard pull. During the same period, a few supply vessels capsized while working the North Sea and other

rough waters. As a result, the classification societies and the United States Coast Guard imposed stiff statical stability requirements upon these vessels. The vessels for which no cross curves were prepared before, now had to be analyzed taking into account the effect of trim at various angles of heels. In the near future, cross curves will have to be prepared taking into account the effect of waves at various positions. All these events gave a small shipbuilder a clear choice of having its own inhouse design and engineering department or using the services of a design agent. The management at Zigler Shipyard decided to have its own design department rather than work at the leisure of an outside design agent.

At Zigler, the engineering staff comprises seven people, four of which are draftsmen. Without the aid of a system such as PRELIKON, which was made available to Zigler Shipyard in April, 1975, through the Maritime Administration, it would be very difficult, tedious and time consuming if one attempted to design a ship and analyze the hull as required.

However, with the aid of PRELIKON, we have designed one ship, and analyzed four other ships that were already in progress, and we are currently working on the design of a 300 ft. ocean going vessel. A small shipyard can have its own effective design and engineering department, maintaining total independence, provided it is backed by a powerful tool such as PRELIKON.

## PRELIKON and Its Capabilities.

The PRELIKON system was developed jointly by Bergen Shipyard of the Aker Group and Det Norske Veritas in Norway. The system was released in 1970. The Maritime Administration (U. S. Department of Commerce) purchased PRELIKON as a part of AUTOKON-71 system in 1973. Realizing that the greater segment of the potential users of PRELIKON were not necessarily potential AUTOKON users, MarAd negotiated with SRS to free PRELIKON from proprietary status, thus making it available to all parties in the United States without restriction.

PRELIKON system consists of a number of applications programs covering a major part of the total design spiral. PRELIKON has its own central data base through which the various program modules communicate. New hull forms may be generated from scratch by reading in offsets or by systematic distortion of a previously designed hull.

The PRELIKON system is divided into three logical groups as follows:

The Input Modules:	Define the Hull Form
The Working Modules:	Perform the Calculations and Prepare the Output
The Service Modules:	Perform Mainly the Data Utility Functions

The Input Modules Consist of:

BV101 : The Main HULL DEFINITION Module  
BV102 : The LINK AUTOKON-PRELIKON Module  
BV105 : The HULL VARIATION Module

The Working Modules Consist of:

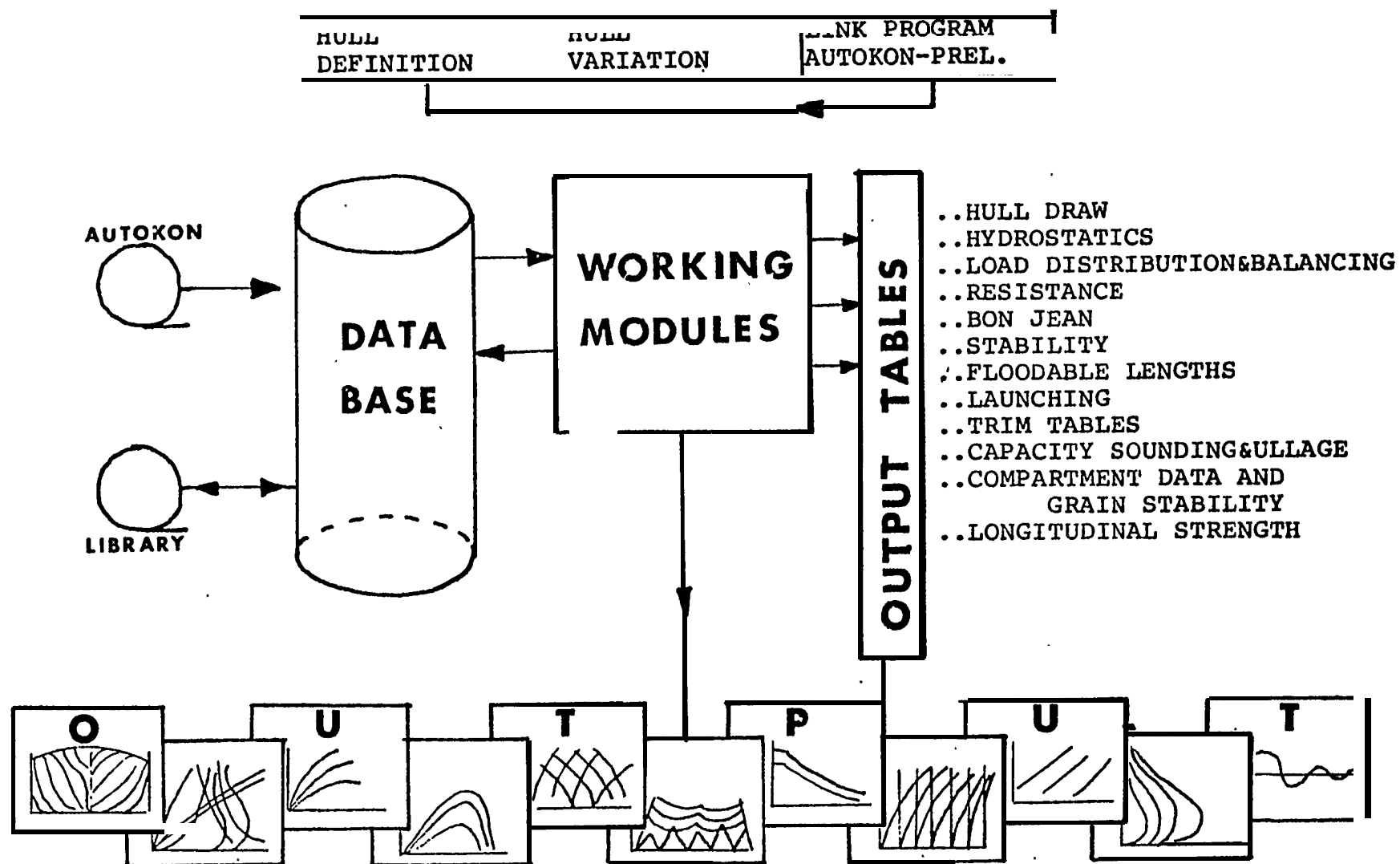
BV110: The HYDROSTATIC Module  
Bv125: The LOAD AND BALANCING Module  
BV130: The RESISTANCE Module  
NV208/NV209C: The BONJEAN Module  
NV210/NV212c: The TRANSVERSE STABILITY Module  
NV215 : The FLOODABLE LENGTH Module  
NV220 : The LAUNCHING Module  
NV241/NV242C : The TRIM TABLE Module  
NV251/NV252: The CAPACITY ULLAGE & SOUNDING Module  
NV253: The COMPARTMENT DATA Module  
NV260 : The LONGITUDINAL STRENGTH Module

The Service Modules Consist of:

NV202 : **The** TAPE STORAGE & RETRIEVAL Module  
NV270 : **The** HULL DATA TRANSFORMATION Module  
SR500: The DATA BASE UTILITY Module

A general description of each of the modules is given in Appendix A of the paper "PRELIKON CAPABILITIES" presented at the REAPS meeting, June 26, 1974, by Mr. Svein Hansen of SRS.

# PRELIKON



## CONCLUSION

Computer applications in shipbuilding are here to stay. Just as Zigler Shipyard has taken advantage of PRELIKON, several other small shipyards can take similar advantage and maintain total independence by having their own design and engineering staff. An inhouse engineering department in a shipyard designs with the particular shipyard practices and constraints in mind. This reduces the communication gap between engineering and production which results in increased productivity.

## ACKNOWLEDGEMENTS

It is a pleasure to acknowledge all the help, stimulation and encouragement that I received from Mr. Jack O. Pirozzolo, the President of Zigler Shipyard. My thanks to Mrs. Vicki Hebert for her excellent work in typing the paper.

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THE NAVY's CABLING AND WIRING COMPUTER PROGRAM  
(Known as C/W)

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## I. INTRODUCTION

In the mid 1960's the Computer Aided Ship Design and Construction project office, located in the Naval Ship Engineering Center, was chartered to apply computer aiding techniques to all phases of the naval shipbuilding process. A preliminary cost analysis in the electrical/electronic discipline pointed out the large amount of manual effort and time spent during installation design and production in the area of equipment cabling and wire hookup. After the aerospace industry's success in developing a productive wiring data system and an in-depth NAVSEC sponsored study at three designated naval shipyards of the cabling/wiring flow process during installation design, it was determined that a similar system should be developed for naval ship design and production. Because there are significant differences between 'wiring an aircraft and wiring a ship, a direct conversion from one application to the other was ruled out.

### Initial System Development

In 1965 the Westinghouse Electric Corporation was selected to develop a system of computer programs for processing the flow of electrical and electronic cabling/wiring information used in ship construction. This system was a major undertaking and addressed the entire process of installation design of equipment on board any Navy ship. This included, such functions as cable routing, hanger selection, penetration design, planning and estimating supporting documents and the equivalent of all the necessary wiring plans. The objectives of the task were to:

• Aid the following production functions:

• Bulkhead penetration layout for thru ships cable

• Installation of thru ships cable

• Planning of local (within compartment) cable installation

• Equipment installation

• Equipment hookup

• Assist E/E design sections:

• Compartment arrangements

• Equipment selection through use of an automated equipment catalog

• Checking production information

- Analytical design calculations (cable routing, voltage drop calculations)
- Aid Planning and Estimating Sections:
  - Start procurement of long lead time items
  - Prepare material and progress lists and job order forms

#### Test Implementation

The initial system was test implemented at two private shipyards, Avondale and General Dynamic/Electric Boat Division and at the Philadelphia Naval Shipyards. As a result of this trial implementation the system was shown to be too much, too soon. Aside from the normal problems associated with implementing a large computer software system, the test implementation showed that more work was needed in the planning and estimating area, and the data input required for cable routing was prohibitively large. The wiring section of the system performed very well.

#### Concentration On Local Layout and Installation

Following the initial development and test period by Westinghouse, Puget Sound Naval Shipyard was tasked to limit the system to those functions which indicated a ready acceptance and immediate payoff and to orient it to the Naval Shipyard environment.

The principal objective of the redirected Cabling/Wiring (C/W) system is the creation of a central configuration data management capability which will reduce drawing and installation time as well as revision and data transfer errors.

#### TI. INSTALLATION PROCESS

The process of installation design for electrical and electronic systems of new ship construction and major ship conversions are very similar given that the cableways have been established. The preparation of control documents begins just as soon as the information is available. In the case of conversion work the documentation available seldom reflects the "as wired ship", except for those specialized systems which have their own configuration management procedures. Also with conversions, there is a problem of ship checking before design. This problem can be alleviated through better life cycle change control. Assuming that all available information is correct, the process will provide the three production drawings that are required:

The equipment arrangement drawing is used to maintain interference control. A system designer requiring space must obtain a location from the arrangement designer. Controlled allotment of the finite volume available precludes physical interference at the time of shipboard installation. Architectural sketches are used to show the prospective locations of the various systems' equipment in the same compartment.

The Block or Isometric Cabling Diagram is required for both naval and

commercial vessels. It is a pictorial/tabular listing of how the equipment is to be interconnected in relation to the ship's hull. It contains a complete material record for a particular project or circuit. All material is purchased from information supplied on this drawing. E/E weights and moments are also usually recorded on the drawing and are used for weight control. The drawing does not show the physical relationship of E/E equipment on board ship. It is intended only to show cabling between systems and the cables' installation requirements.

The Elementary Wiring Diagram is primarily a registry for the disposition of each wire in every cable in a particular circuit.

The order in which the drawings are generated varies-according to the method of the system design. For instance,. if it is designed from the end points back, such as power distribution or dial telephone, the sequence of the production drawings is different from the electronic system which is predefined. Predefined systems have most of the elementary wiring diagrams and room arrangement drawings provided at contract award time.

Specialized drawings such as foundation requirements and component assembly are supplied by the manufacturer and in some cases developed by the design codes from available information.

The primary objective of the drawings is to provide as much necessary information as possible using a minimum of detailed drafting. The drawings are composites of information required by several design and production users.

Therefore it is necessary for the individual user to cull out those portions that are of interest to him. For each such extraction, the probability of error is increased. Plainly there is needed a method to eliminate transcription errors and to ensure that work is being done to a consistent revision level.

The three drawings are referenced by the craftsmen to provide the information to perform the following tasks:

- Determine cableway routings and cableway penetration area clusters or riser boxes and install cableway support hardware at water tight decks and bulkheads.
- Pull cables that traverse compartments and decks, larger and longer cables first and establish breakouts (points where cables enter and exit a cableway).
- Pull within compartment (local) cables and cables which do not traverse cableways.
- Install connection boxes which link sections of cables. Cut cables.
- Begin installing equipment (all hardware, except main cables, is usually brought to an individual compartment as a package wherever possible).

- Fabricate plug ends on cables for all plug-connected equipment.
- Ring out wires in cables, prepare wire ends for hookup, apply branded sleeving wire markers (floaters) to wires.
- Close off transit devices, install cable markers, tie down cable groups in cableways.
- Complete all hooking up and labeling.
- Conduct installation testing: passive test for continuity of circuits, active tests of selected subsystems for correct equipment operation.

### III. PROBLEM AREAS

#### Design

The designer has the responsibility to develop the production type documents that reflect changes to the system. Getting the most current revision level of the drawings signed out and to the shops is a problem whenever the change must be cross referenced with many other production drawings. There is always the chance that composite type data can be extracted from drawings which are not at the current revision levels. This type of problem can be alleviated by having some method of producing all the necessary drawings at the same time from one source of information.

The designer puts out the job order description for the craftsman and the list of drawings needed for the task. The designer's time can be reduced by giving him the ability to ask for different documents which can describe:

(1) the circuits listed in the job order description, (2) the parts of a circuit or system, (3) the entire circuit or system.

The job order description lists those drawings that have been determined by the designer to be necessary or of value to the appropriate waterfront crew. Because work methods between installation crews vary, those designers not familiar with the different work crew methods may not list all drawings that may be useful to the crew in question. This becomes a significant factor when the shop must manually prepare an Equipment Terminal Layup for a large installation such as a fire control switchboard.

#### Craftsmen

The craftsmen must reference multiple drawings to develop a working sheet for the installation. A good example is the development of an Equipment Terminal Layup List. The craftsmen must reference sheets of wiring tables that are not always ordered such that they correspond to the sequential task of hooking up each terminator.

In some yards a card is prepared with all the composite type data for each cable of each IC, ECM, Radar, Electronics or Weapon System. These data are then sorted by equipment and printed out as a separate list. This is to get hookup data for one piece of equipment, and even then the data is not necessarily in proper hook-up sequence. What is needed is a scheme for the engineer to selectively produce a document having not only selected system information but also the correct order of hookup information. Thus the craftsman may install the wire connections in a sequential rather than haphazard order.

#### IV. C/W AND THE INSTALLATION FLOW PROCESS

The Cabling/Wiring System (C/W) aids the installation process providing the electrical and electronic information on listings which can be arranged into issuable work packages for installation.

The system is not (as yet) an analytical design system. The design is done by the engineers and designers. Only the organization and manner of the presentation of the information is changed from the customary elementary wiring diagram and isometric drawings to computer input and output listings, with the added advantage that the data elements of the input information be recorded just once.

The C/W System utilizes a master drawings file containing connection data. This data can be retrieved quickly and manipulated to produce many formatted output documents with minimum effort to prepare drawings for the different functions of production.

##### Input Data Requirements

The designer responsible for each system must identify the material to be presented on the drawings (listings) produced by C/W by using keypunch forms designed for use with the program. For each electrical/electronic system the designer must enter the minimum information required to obtain necessary installation work package drawings. This information may vary from ship to ship or from system to system, but for the most part, consists of four kinds of information:-

- (1) General drawing information such as the systems weight group, general notes, references, and NAVSEA drawing number.
- (2) Equipment information such as the description, location, and weight of equipment.
- (3) Cabling and wiring information such as the identity of the equipment connected on each end and the conductor termination points within each piece of equipment.
- (4) Procurement information such as the specification and grade or manufacturer's name and part number for each different type of material.

This information provides the groundwork from which all documents are prepared. The designer must identify and describe the individual items or components used in his system. Through the use of C/W, the designer is provided with a capability to consider only part of his system at a time. Cards used to describe an E/E circuit or system are collectively referred to as system definition cards and are the vehicle by which the designers get the information into the program. Output from the system is requested for a specific document by circuit or system.

#### Hierarchical Arrangement

Before a job can be submitted for processing by C/W, the input cards must be arranged in a sequence of hierarchical levels. This allows the user to describe an item at one level in terms of the items at successive lower levels. For example, an electrical/electronic system is described in terms of its equipment and cable data. In turn, each cable is broken down in terms of its note and conductor data.

A data file is built for each ship and consists of catalogs containing fixed data, e.g. equipment attributes, and circuit data about each electrical/**electronic system to be installed or modified.**

#### Automatic Lookup

Automatic catalog lookup is utilized for preparation of requested output documents called drawings to obtain additional information on those equipments and cables entered by the designer for each system stored on the file: This frees the designer from the time consuming task of manual lookup.

#### Document Variety

Information either entered by the designer or obtained from the catalogs, is used to produce a wide variety of documents. These documents are tailored to furnish the recipient with the information necessary to do the task.

The C/W master drawing file consists of most of the information contained on the three basic drawings traditionally used to prepare work packages.

The system currently produces the following documents:

(1) Wiring Table. A tabular listing of the detailed wiring connections necessary to hook up each cable in the electrical/electronic shipboard systems. Fig (1).

(2) Cable Installation Guide. Assists in the preparation of ships' compartment electrical layout.

(3) Equipment Cabling List. Shows the interconnecting local cabling between equipments in each compartment. Fig. (2).

- W I R I N G   T A B L E S

- U N I T   A -  
MK 140 AMPLIFIER

- U N I T   B -  
ATTACK CENTER SWBD  
MK 41 MOD 3

- C A B L E -  
N O .  
SYS. 6R-6PA-GAP  
REF 10. 10DO4  
TYPE. MSCA-19  
G-GAP4

NO. 3504

NO. 3334

UNIT A TERM	WIRE MARKING	WIRE COLOR	GROUP	UNIT B TERM	WIRE FUNCTION	REF
2-3-05	17GAP28	BK	1	2FE-13	*26VDC COMMON	101
2-3-09	17GAAP21OI	WH	2	2FN-04	GYRO ANGLE MARK 360 DPR TU 2	102
2-3-01	17GAAP102	R D	3	2FN-05	HVM MARK HIGH TUBE 2	103
2-3-08	17GAAP2103	GR	4	2FN-06	HVM MARK LOW TUBE 2	104
2-3-04	17GGAP821	OR	5	2FB-10	GYRO ANGLE LIMIT TUBE 2	105
-----						
2-3-03	17GAAP822	8L	6	2FB-11	RUNNING DEPTH LIMIT TUBE 2	106
2-3-02	17GAAP823	WH-BK	7	2FB-12	ENABLING RUN LIMIT TUBE 2	107
4-3-05	17GAP40	RD-8K	8	2FE-14	+26VDC COMMON	108
4-3-09	17GAAP4101	GR-8K	9	2FN-10	GYRO ANGLE MARK 360 DPR TU 4	109
4-3-01	17GAAP4102	OR-BK	10	2FN-11	HVM MARK HIGH TUBE 4	110
-----						
4-3-08	17GAAP4103	8L-8K	11	2FN-12	HVM MARK LOW TUBE 4	111
4-3-04	17GAAP841	8K-WH	12	2FE-10	GYRO ANGLE LIMIT TUBE 4	112
4-3-03	17GAAP842	RD-WH	13	2FE-11	RUNNINH DEPTH LIMIT TUBE 4	113
4-3-02	17GAAP843	GR-WH	14	2FE-12	ENABLING RUN LIMIT TUBE 4	114
*	NONE	BL-WH	15	*	SPARE	115
-----						
*	NONE	BK-RD	16	*	SPARE	116
*	NONE	WH-RD	17	*	SPARE	117
*	NONE	OR-RD	18	*	SPARE	116
*	NONE	BL-RD	19	*	SPARE	119
-----						
* TIE BACK AND INSULATE						120
NOTE I-THIS SHEET REFLECTS ORDALT 7188.						121

Figure 1.

CABLE. 6-GAP4

NAVSHIPS DRAWING NO. REV -SHEET-



FROM EQUIPMENT	TERM POINT	PLUG SYMB	CABLE NUMBER	CABLE TYPE	SIGNAL STATUS	CABLE STATUS	LENGTH (FEET)	TO EQUIPMENT
-----								
--- CABLES TO EQUIP IN ---								
COMPT.								
No. 3001			R-EZ13.	MSCA-19				
			<b>P-EZ9</b>	<b>TSGA-23</b>				
			<b>R-EZ7</b>	<b>TSGA-14</b>			PDB-1	
NO. 3002			R-EZ52	FSGA-9			PDB-6	
--- CABLES TO EQUIP IN --								
COMPT. 03-99-0-C								
No. 3003			R-EZ130	<b>MSCA-24</b>				CONSOLE RADAR SET
			R-EZ131	<b>MSCA-14</b>				OJ-227
			R-EZ132	<b>FSGA-3</b>				
			R-EZ133	<b>FSGA-9</b>				
			R-EZ134	<b>FSGA-9</b>				
			R-EZ135	<b>FSGA-23</b>				
			R-EZ136	<b>FSGA-23</b>				
			R-EZ137	<b>FSGA-23</b>				
			R-EZ138	<b>TTRSA-12</b>				
----- LOCAL CABLES -----								
			<b>R-EZ110</b>	<b>3SWA-3</b>				
			<b>R-EZ124</b>	<b>SPECIAL</b>				
			<b>R-EZ125</b>	<b>SPECIAL</b>				
			<b>R-EZ62</b>	SSGA-100				
			<b>R-EZ53</b>	FSGP-4			PDB-6	
			<b>R-EZ58</b>	<b>TSGA-3</b>				
			<b>R-EZ164</b>	<b>TTRSA-12</b>				INTERCONNECTION BOX
								KCMX1
--- CABLES TO EQUIP IN ---								
COMPT. 1-130-2-C								
No. 3004			<b>R-EZ155</b>	<b>RG12A/U</b>				VIDEO AMPLIFIER
			<b>R-EZ158</b>	<b>RG12A/U</b>				AM-1914
			<b>R-EZ168</b>	<b>MSCA10</b>				SYNCHRO AMPLIFIER
			<b>R-EZ173</b>	<b>DSGA-3</b>				MK2 MOO 2A

Figure 2.

(4) Equipment Terminal Layup List. Assists the electrician in hook-up of connection boxes, switchboards, and other large on-board equipment.

(5) Equipment Cable Floater List. Provides marked sleeving information for individual wire markers.

(6) Connection Box Termination List. Assists the engineer or electrician in laying up connection boxes frequently installed in electrical/electronic systems, such as interior communications, fire control and dial telephone systems.

(7) Circuit Check List. Aids the engineer and electrician in tracing any circuit installed in a given system.

(8) Equipment Terminal Locator Guide. Assists in tracing the point-to-point path through connection boxes and switchboards of each circuit installed with the equipment.

(9) Ship Equipment List. An inventory of all the equipment either installed or to be installed.

(10) Cable Catalog List. A listing organized by cable type and size of the standard Navy cables used on board the ship.

Additional documents can easily be formatted and retrieved from the data base as need for them arises.

#### Revision Capability

C/W System is capable of almost infinite revision in its output. A keypunch operator can easily make up the revision cards from a copy of the output sheets marked up by the engineer to show the desired changes. The system will accept commands that will cause it to erase, add, correct, relocate, and/or re-designate. This is done simply by requesting a change for only the data elements effected. The entire system description need not be corrected. Just as a designer would not prepare a new drawing to change a wire number, he is not required by C/W to re-run the entire deck in order to achieve the equivalent of a drawing revision. The update operates with only the new data and a request to make the substitution. This feature provides for easy creation and rapid revision.

#### Missing or Invalid Information

C/W is designed to execute to completion on every computer run, regardless of errors which may have been punched in the cards. Missing or invalid information of practically any kind will not hinder normal processing. Diagnostic messages are printed to point out bad information in the submitted data, but do not stop execution. C/W continues to execute all processable data, leaving blanks whenever it encounters insufficient information. For example, a check is made to insure that the input length of a cable is actually a numerical value. If not, the program will in turn: inform the designer, blank the length, and

continue processing. Furthermore, if a revision is desired, two additional checks will be made. First, the drawing revision letter is checked to insure that it is actually alphabetic characters excluding the characters I, O, Q, and S, and second, the revision letter must be in proper order, that is, greater than or equal to the previous revision. If either check fails, the designer will be informed and the revision will not be made.

#### Fatal Errors

Certain errors, such as trying to modify the master file created for another ship, will cause the program to abort. These errors are termed "fatal errors".

#### Program Anticipation

If cards are discovered to be arranged improperly, the program will default to values that will allow partial output to be provided. These default values can then be easily identified and corrected. The arrangement or correctness of the input card deck is validated by the program. For example, if the designer fails to identify either or both equipments connected to one of the cables, an error message will be printed and the program will continue to process. Wiring tables will be printed for this cable, without the description and location of the unidentified equipment.

The intent is to process to completion partial circuit data and then complete processing in a later computer run.

#### Benefits

##### Where Was It Used

The following is a chronological list of ships for which the cabling/wiring system was used on various circuits at Puget Sound Naval Shipyard from 1970 to the present:

SSN	590	SSBN	608
CGN	25	SSBN	644
CV	63 (2 Overhauls)	SSBN	654
CV	64 (2 Overhauls)	SSBN	657
AOE	1	SSN	652
AOE	2	CGN	35
CGN	9	AS	32
CV	61	DDG	15
SSBN	623	DDG	16

It also has been used at Philadelphia Naval Shipyard on LCC 19 and at Charleston Naval Shipyard on CG 19.

The C/W System is now being implemented at Norfolk and Long Beach and is scheduled for implementation in the other naval shipyards.

#### C/W System Implementation Support

Philadelphia Naval Shipyard has been tasked, as the Navy's C/W Tech Agent, to provide limited support to all shipyards during implementation. General Dynamics/Electric Boat has now implemented the system and, as a test, has produced Trident wiring tables.

#### Audited Savings

There exists no benefits data derived from the utilization of the present system because there has been no recent audit of the system. However, meaningful benefits data was derived for the predecessor of the C/W System. This is the information being presented here in Table 1. It must be understood that the predecessor "Wires" was not as refined nor as user oriented as C/W and, therefore, gives a very conservative approximation of what can be expected.

The sum of \$971,938.000 of ship alteration funds was involved on four separate projects with dollar cost saving accrued of \$80,492.00. This indicates an average of 8.28% savings for each project processed by the system. The cost and savings data are based on actual audited costs for the WIRES system and the manual system it supplanted.

#### Future Use

The master drawing file is maintained during the construction or conversion/overhaul period for each ship processed. Measures are being taken whereby this file will become part of the ship drawing index and retained at the planning yard.

This file along with the plans can be used as a foundation to build new files for other ships of the same class. This is where full implementation of C/W system enters into the picture. The ultimate goal is to develop a file during the construction period and make it available in the future to the shipyard during conversion or overhaul.

#### Conclusions

This system is the first of what the author hopes will be a large number of computer aided ship design and construction programs to be developed and implemented by the Naval Sea Systems Command. It is expected that by applying these systems deliberately and diligently in an integrated shipyard modernization program, the total benefits of electronic data processing can be obtained, thus producing a better ship faster and at a lower cost.

SYSTEM	PRODUCT	COULD COST	DID COST	SAVINGS	ALLOWED
AN/SPN-42 RADAR	DEVELOPED CBOX DEFINED JUN BOX DELETED CABLES WIRE LISTS		--	---	\$182,000.00
		\$ 3,300.00	\$1,863.00	\$ 1,467.00	
		6,994.00	0.00	6,994.00	
		26,928.00	6,038.00	20,890.00	
		TOTAL ESTIMATED SAVINGS		\$29,351.00	
DIAL TELEPHONE	WIRE LIST WIRE LIST TERM. LAYUP LIST				(\$ 6.12% OF ALLOWED)  \$276,516.00
		3,388.00	4,030.00	- 642.00	
		3,836.00	0.00	3,836.00	
		TOTAL ESTIMATED SAVINGS		\$ 3,194.00	
				1.25% OF A (NWFN)	
USS CONSTELLATION					
AN/SPN-42 RADAR	BOX JUMPERS SHIELD RE-ORDER PLUG RE-ORDER ISSUED DRAWINGS SHOP LABOR	3,067.00	0.00	3,067.00	\$237,600.00
		99.00	34.50	64.00	
		4,136.00	1,654.00	2,481.00	
		26,929.00	3,441.00	23,487.00	
		---	---	3,663.00	
TOTAL ESTIMATED SAVINGS		\$32,767.00	(13.79% OF ALLOWED)		
DIAL TELEPHONE	WIRE LIST TERM LAYUP LIST CIRCUIT CHECK LIST SHOP LABOR	3,836.00	3,386.00	450.00	\$275,822.00
		3,836.00	0.00	3,836.00	
		3,836.00	0.00	3,836.00	
		---	---	7,051.00	
		TOTAL ESTIMATED SAVINGS		\$15,185.00	
TOTAL SAVED \$60,492.00					
TOTAL AMOUNT INVOLVED \$971,938.00					
AVERAGE SAVINGS 8.28%					

Table 1. SAVINGS RESULTING FROM THE USE OF WIRES

NASSCO ORGANIZATION FOR  
THE SPADES SYSTEM

George A. Uberti  
and  
Jack Wasserboehr  
National Steel and Shipbuilding Company  
San Diego, California

Mr. Uberti is Chief of Development Engineering, responsible for managing the computer support group. Formerly, he was Chief Marine Engineer at NASSCO. Prior to joining NASSCO, Mr. Uberti had over ten years experience in marine and nuclear engineering, research and development. He received his B.S. degree in Marine Engineering from the U.S. Merchant Marine Academy and his M.S. from MIT.

Mr. Wasserboehr is a Senior Programmer Analyst handling scientific/engineering applications at NASSCO, where he has worked for over ten years.

Two years ago, Nassco contracted for the unrestricted *use of* the SPADES system for ships under construction in the shipyard. As we set out to use SPADES, an internal company organization for its use emerged, resulting in an effective working relationship among the various departments of the company. These departments are Engineering, Production, and Computer Services.

SPADES was installed at Nassco as we were constructing our first two lines of tankers: the "handy" size Coronado Class and the Panamax size San Clemente Class. Since these ships were caught in the transition, N/C tapes were produced without full benefit of the SPADES modules. Data bases were established by digitizing on the Coronado and by loading on the San Clemente. Construction is underway for our third class of tankers, the 190,000 DWT San Diego Class, and we *are* making fuller use of SPADES on these ships.

Through SPADES, the San Diego lines were faired, the data base was established, and naval architecture calculations were made. Steel parts are being generated, nested, and burned.

Plates are being developed and rolled. Frame bending information is produced and used, although at this time we do not have a frame bender. The pin jig module is in the final stages of development and de-bugging, and we expect to produce pin jig dimensions in time to support the construction schedule.

The Nassco organization for SPADES evolved along regular functional lines within the departments affected. Loftsmen, who used to make full size wooden templates on the mold loft floor, are now the N/C programmers who cause the N/C tapes to be made. Engineers, who issue preliminary unfaired ships lines, are now able to complete the job, since the fairing operation does not require a drafting board the size of the mold loft floor. Computer service personnel, who run the company computer, have added SPADES to the services they provide. And finally, the responsibility for control of the SPADES system is assigned to the Computer Support Group in the Engineering Department, which has charge of all scientific and engineering programs used by the Engineering Department.

A word of explanation regarding the functions of the two "computer groups" as mentioned above is in order. *The Computer Semite* Department is a *major service* department of the company. As such, it owns the company computer and operates the **company's** administrative, accounting, and management systems. It provides computer programming services for



all departments in all areas except for scientific and *engi-*neering calculations. Scientific and engineering programming and related systems analysis are performed by a small Computer Support Goup within the Engineering Department. Most of this work is in FORTRAN, as are the SPADES programs.

For most effective use of SPADES at Nassco, we have defined four company functions as illustrated by the boxes in Figure 1. Lines of communication among them have been established, as well as with the consultant, Cali. and Associates. The total operation is user-oriented, providing support and services as needed.

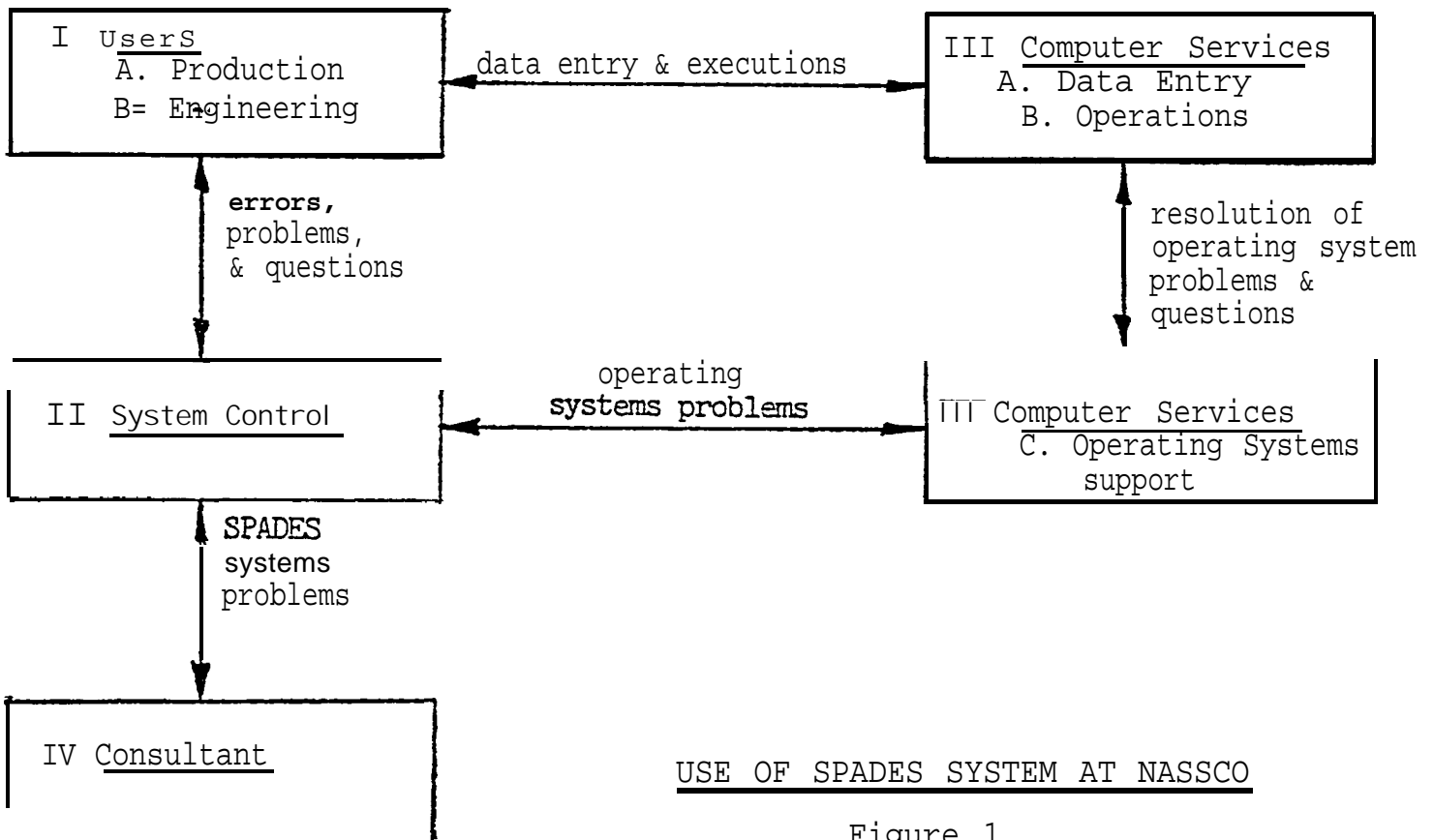
The user *functions* are divided between engineering and production. There are eight SPADES modules, three of which are primarily used by the Engineering Department, three primarily by the Mold Loft, and two used jointly or by either as needed.

The three engineering modules are: the Fairing and Drawing module, which fairs the hull, generates and loads frame definitions, and draws body plans; the Hulload module, which defines and loads the **remaining** ship geometry; and the Hullcal module, which is a package of naval architecture routines.

## FUNCTIONS

- I     Users
  - A.   **Production - Mold Loft**
  - B.   Engineering - Hull Division
- II    System Control
  - A.   Engineering - Computer Support Group
- III   Computer Services
  - A.   **Data Entry**
  - B.   Operations
  - C.   Operating Systems Support
- IV    Consultant
  - A.   Cali and Associates

## LINE OF COMMUNICATION



USE OF SPADES SYSTEM AT NASSCO

Figure 1

The three modules used by the Mold Loft are: Part Generation module, which produces information and a tape for drawing the part; Nesting module, which produces a tape of nested parts for the burning machine; and Plate Development module, which produces tapes for burning shell plates.

The Manufacturing Aids module is used jointly by Production and Engineering. This consists of four programs.

The first of these prints the offset booklet; a second calculates pin heights for the pin jig; a third prints girth length tables; and the fourth calculates and draws frame bending information.

Another joint-use module is the Utility module. This is a group of five programs used for direct access to the data base. This group is needed to accomplish such tasks as initialization for a new ship, reports of information stored on data base, new copies of output tapes, copying an input deck to a new name, and modifying or adding an input deck for later execution.

It should be noted that the Engineering Department fairs the lines, loads the data base, and keeps it up to date. Access to the data base for making changes is limited to the Engineering Department.

The SPADES programs are currently being executed on NASSCO'S own in-house computer. This is an IBM/370/145 DOS virtual storage computer. The peripheral equipment directly used in conjunction with this computer are a card reader, a line printer, a card punch five tape drives, and twelve disk drives. The SPADES output from this computer consists of printed information and punched cards. The punched output is then converted by the Mold Loft equipment into paper tapes which can be used on the drafting machine and, when applicable, on the burning machines.

Figure 2 shows an approximate physical layout of the terminal, mini-computer, and drafting machine equipment installed in the mold loft. It shows also the processing flow from the N/C programmers through the equipment to the drafting and burning machines. The central unit in the system is the mini-computer, which is programmed to control the processing and flow of information through the system. The system permits the simultaneous use of the drafting machine and terminal equipment (card reader, line printer, paper tape punch).

Nassco's Computer Service Department is currently investigating the hardware and software requirements to connect the Mold Loft equipment to the 370 system through a data phone. The software required seems to be the major problem at this time.

BEGIN

INPUT FORMS  
ARE CODED BY NC  
PROGRAMMERS  
IN MOLD LOFT

NOTE :

HAND TRANSMITTAL IS  
INDICATED BY DASH LINES.

SHORT JOBS  
ARE PUNCHED  
IN MOLD LOFT  
  
KEY PUNCH

LARGE JOBS ARE  
SENT TO COMPUTER  
SERVICES FOR  
KEYPUNCHING

JOBS ARE THEN  
EXECUTED ON  
NASSCO'S IBM 370  
COMPUTER. SHIP  
INFORMATION IS  
LOADED TO THE  
DATA BASE.  
PUNCHED OUTPUT  
CARDS AND PRINTED  
INFORMATION ARE  
PRODUCED.

CARD  
READER

DATA PHONE

LINE PRINTER

PAPER TAPE  
PUNCH  
  
MINI  
COMPUTER  
CORE  
STORAGE

MINI-  
COMPUTER

CONTROLS  
PROCESSING & FLOW OF  
INFORMATION  
THROUGH SYSTEM

CONTROL  
CONSOLE FOR  
CARD READER,  
LINE PRINTER,  
PAPER TAPE PUNCH  
& DATA PHONE

PUNCHED CARDS ARE  
FED INTO READER  
TO PRODUCE LISTING  
AT PRINTER AND/OR  
PUNCH PAPER TAPE

PAPER TAPE IS PUNCHED

PAPER TAPE FED  
TO PAPER TAPE  
READER/DIRECTOR

PAPER TAPE  
READER/DIRECTOR

DRIVES NC  
DRAFTING  
MACHINE

INFORMATION FLOW THROUGH

SPADES HARDWARE

Figure 2

The SPADES software consists of 840 FORTRAN programs and sub-programs. These routines have one of three classifications: data base routines, general purpose routines, and specific module routines. The last are routines that are used in only one of the eight user modules. The data base and general purpose routines are just what their names imply and, are available for use by any of the eight modules.

The SPADES System is constantly in a state of development as Cali and Associates modify it to correct or *improve* the system. When they come out with a new version or modified routines, Nassco gets a source copy of all affected routines. We received our first version (for the in-house computer) of the SPADES system, consisting of approximately 720 FORTRAN programs and sub-routines, in May 1975. Our current production version was issued to us in December 1975.

In a typical revision of the SPADES system, Nassco receives approximately 50 to 150 new or modified sub-routines, which are then integrated into the current SPADES System to produce the new version. This task is performed by the Computer Support Group at Nassco. Occasionally, between major revisions, Nassco will receive a small number of *new or revised routines* to *correct* a problem or add a new capability. These sub-routines are also added, tested, and debugged by the Computer Support Group.

One of the responsibilities of the Computer Support Group is the maintenance of the SPADES System. This involves providing the user with the most current versions of the SPADES modules, providing the user with the easiest method to use the modules, and keeping the impact of SPADES on our relatively small computer system at a minimum by using it in the most efficient manner possible.

In order to accomplish the above tasks three computer systems libraries are used, and one private SPADES library is used. All source routines are stored on a large card image library. The routines are compiled from this library and the object module is cataloged to the SPADES private relocatable library. Each SPADES module is link-edited and the executable phase is cataloged to the system core image library. We keep three executable phases for each module on this core image library. The first is the current production version, the second is the previous production version, and the third is a test version. All job control language (JCL) required to execute each module is stored on the system procedure (Procs) library. Thus, a user needs only to call for the appropriate Proc to execute the desired SPADES module.

All testing of new or modified versions of SPADES modules, and all the maintenance of SPADES information on the above-mentioned libraries is done by the Computer Support Group.

A logical approach has been developed for the solution of user problems, which may originate in engineering or in the mold loft. The Computer Support Group makes the following interrogations in the sequence listed. The process stops with the first "yes" answer, and appropriate corrective action is taken. All problems to date have been solved by this procedure. only about 20% have gone beyond step 6.

1. Is problem system-related (operations, JCL, etc.)?  
If yes, correct the system problem and resubmit the job in question.
2. Is problem mis-use of a command?  
If yes, inform user of *correct use* of the command.
3. Is problem due to incorrect data base information?  
If yes, notify hull-load group to make correction.
4. Is user under mis-conception of what is actually on Data Base? If yes, get ship file report to show user what is actually on Data Base.
5. If all "no's" Up to this point, then rerun jobs With trace print on to determine more precisely where problem is occurring and to find values of variables at the the of problem occurrence.



6. Does trace print reveal that 1, 2, 3, or 4 is the problem? If yes, then follow ABOVE procedures.
7. Does trace print reveal a bug in the SPADES program? If yes, then pinpoint the bug, determine a solution, and notify appropriate person at Cali & Associates to get approval for solution.
8. If all "no's" up to this point, then Engineering Computer Support Group is unable to completely resolve problem. Call appropriate person at Cali & Associates.
9. Were Cali & Associates able to solve problem over phone? If yes, implement the change.
10. If all "no's" up to this point, then mail all applicable information and trace print to Cali & Associates for more detailed investigation.

We have found that the Nassco organization and procedures described above work effectively for the SPADES system as currently configured. New SPADES developments are in the works, and we expect that they will continue to be handled as at present. We can foresee new shipbuilding, applications as SPADES begins to do more things, perhaps in piping, ventilation, or electrical areas. When this comes to pass, new user groups in the departments affected would be given access to SPADES, retaining the functional organization that appears to work well.

## ORGANIZING FOR NUMERICAL CONTROL PRODUCTION

Vincent H. Nuzzo  
Avondale Shipyards  
New Orleans, Louisiana

Mr. Nuzzo is the Assistant Superintendent of the Mold Loft and Director of Numerical Control. He has 23 years experience in the mold loft at Avondale and has spent the last ten years in developing the usage of numerical control.

What is the optimum organizational pattern for NC in a shipyard? In an attempt to answer this question, we carefully reviewed our NC operations at Avondale.

Ok.  
let's not.  
Let us regress to 1938, when Avondale began. Avondale Marine Ways purchased the equipment once used to ferry railroad cars across the Mississippi River, and started a marine repair service. Later, as work increased, small boats and barges were constructed.

Today's facility is a modern shipyard employing 8500 workers, and is Louisiana's largest private industrial employer.

In the last ten years Avondale has constructed a large variety of ships.. Destroyer escorts and Coast Guard cutters, as well as commercial oil and cargo carriers, have been delivered. Among our more recent accomplishments is the completion of a large number of LASH vessels and semi-submersible drilling rigs. Presently, we have in service a 900' floating drydock, built by Avondale, to accommodate the launching of the LNG ships now under construction.

By the mid-1960's, we were successfully utilizing engineering and hull calculation programs. Our IBM 1401 computer was performing tedious and time consuming calculations quickly and accurately.

At this time, we signed a contract to construct 27 destroyer escorts. These ships had very complicated webs of 3/4" plate in the sonar domes that would require many man-hours to burn. To cut these webs, an Airco Servograph machine was

purchased. This was our first attempt at automatic burning. Full size templates, drawn with ink on opaque film, were needed to control this machine. Since these templates were very costly to produce by hand, we turned to our computer. A simple program, designed to generate a curve, fit a radius in a corner, and draw a hole, was developed to aid in producing the templates used by the servograph machine. The program generated a paper tape for producing full size templates on a leased 4'x5' Kongsburg drafting machine.

With the advent of supertankers and the outlook for new and larger contracts, Avondale embarked on a \$32,000,000 expansion program. Limited acreage and larger ships prompted a need for a highly efficient method of cutting steel. Thus, Avondale turned to NC. Property was acquired for a new plate shop, fabrication area, and steel storage facility. Modern steel handling equipment was purchased, and a Kongsburg drafting machine and director were installed. Two Messer Griesheim burning machines and two flame planers' were also put into operation.

While this equipment was being installed, our "in house" program was being improved with new commands and features. Working with the Mold Loft in a production oriented environment, our programmers created a system that served us well for the next seven years.

Originally,. NC responsibilities were shared by engineering and production personnel. However, because of work schedules and a knowledge of lofting practices, the Mold Loft assumed

a substantial role in Avondale's 'NC development. Later, it became evident that in order to maintain production schedules, it was necessary to further centralize NC operations. Today, with the exception of the Scientific and Computer Applications sections, NC is an integral part of production operations.

In 1973, Avondale contracted with Cali and Associates, to develop and install Avondale "SPADES."

To date, with the "SPADES" system, LNG tankers, drilling rigs, large and small barges, and our drydock have been successfully completed. Presently, we are working on four 164,000 DWT tankers;

Since the division of responsibilities differs from shipyard to shipyard, let us now look at Figure 1 which depicts the structure of each management group at Avondale - Administration, Engineering, and Production. It is interesting to note that our computer is being controlled by the Administrative group rather than by Engineering. This condition exists because our computer was primarily used for administrative type programs before engineering and NC programs were present at Avondale.

There are four NC related departments under the Engineering Vice President.

### Computer Applications

The task of the Computer Applications Section is the development of software for any shipyard function that can be computerized. This department also has personnel working with

AVONDALE'S ORGANIZATIONAL STRUCTURE OF N.C. RELATED DEPARTMENTS

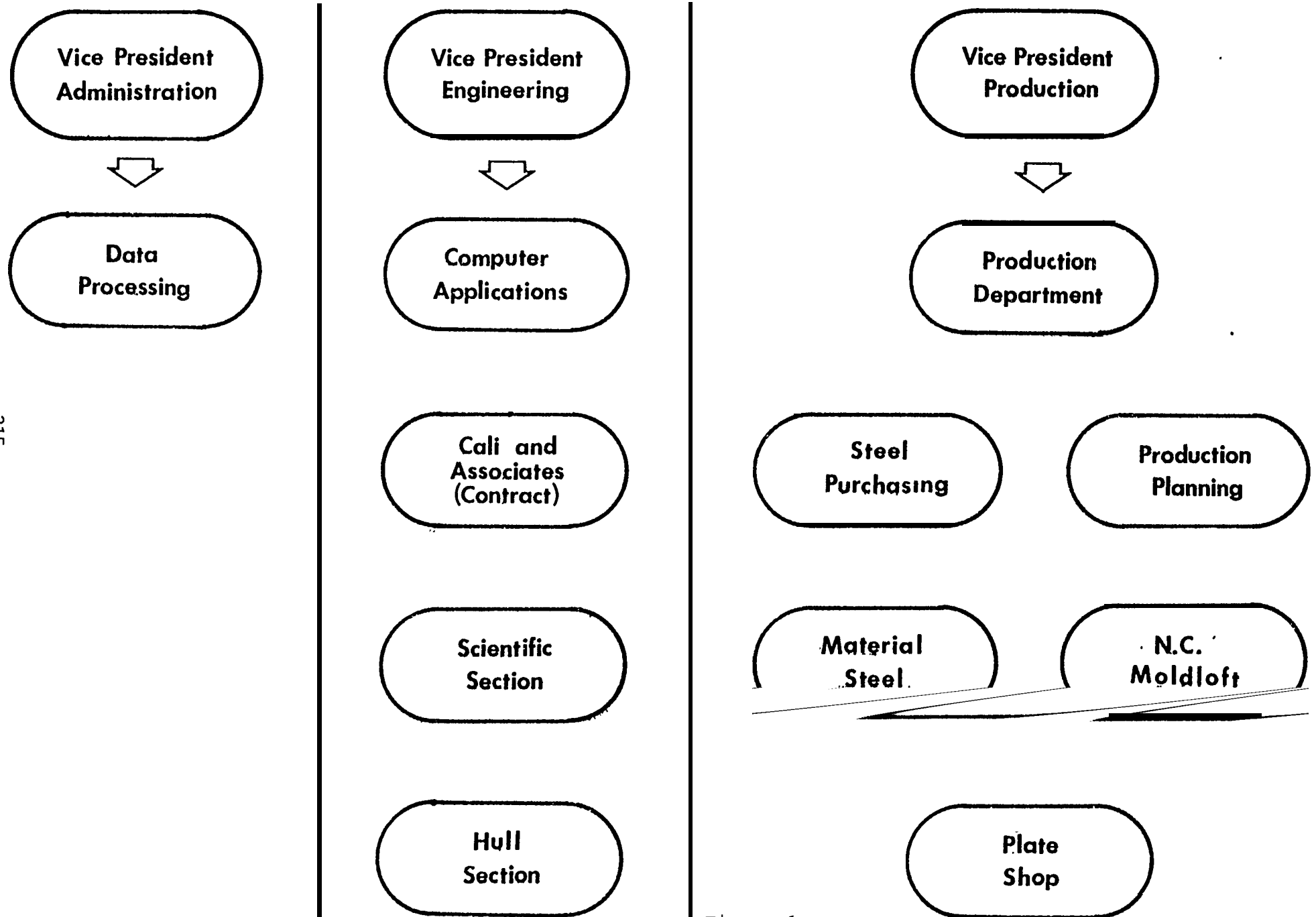


Figure 1.

modifications to "SPADES."

Computer Applications is also responsible for fairing the ship's envelope, generating the frames, and producing offsets for engineering and the field. Computer Applications is equipped with a Kongsburg 8 'x12 '. drafting machine, Kongsburg director, and an IBM System 7 satellite unit. Management is now reviewing the possibility of shifting the fairing responsibility to Hull Engineering or the NC Mold Loft.

#### Cali and Associates

Cali and Associates is under contract to Avondale for the development and maintenance of our NC system. In addition to NC responsibilities, Cali and Associates is also responsible for the development and maintenance of the hull calculation programs. This organization, along with Avondale personnel, is in the process of developing other new programs.

#### Scientific Section

Basic structure and hull design is the primary responsibility of the Scientific Section. These tasks are accomplished by use of the "SPADES" hull calculation program and a number of programs developed by Avondale.

As the first users of the data base , their structure design is oriented so that blueprint involvement and parts generation are geared for NC production. Information for the

data base, such as stringer locations and sight edges, is also acquired from this group.

### Engineering Hull Section

Engineering detailing and blueprint production is the job of our Hull Section. Working closely with the Production Department, Production Planning, and the NC Mold Loft, information vital to our field operations is gathered for refining the hull drawings.

Emphasis is placed on standardization; items such as holes, brackets, cut-outs, and webs are designed to complement our NC operation.

With a decreasing work load, our hull engineers were recently able to go through a brief NC training period. The purpose was to acquaint the draftsman with the wealth of information available in the data base and to introduce him to the NC tools available for his use. Certainly, this will help him in creating drawings that are pictorially and dimensionally accurate.

The steel take-off group is also a part of Hull Engineering. By utilizing the "SPADES" shell plate program, exact shell plate sizes are obtained. Hull engineering and scantling drawings are used for the balance of the steel take-off. These People prepare the original bill of materials for every job.

There are six NC related departments under the Vice President in charge of Production.



### Production Deptment

The production Department's function is to organize and control all phases of production operations in the yard.

Numerical control contributes to their operation by furnishing valuable information for production work. Sketches of burning tapes with computed burning time, quantity of plates to be cut., and an accurate representation of the steel part are important aids in the issuance of work orders.

The format of work orders has also changed because of NC. Work orders were issued by drawing, detail, and piece numbers; they are now issued primarily by tape numbers.

Using NC sketches, the production engineer can carefully monitor the allotment of man-hours needed by the plate shop, thereby increasing plate shop productivity.

### Steel purchasing

The Steel Purchasing group, working with Production Planning and Material Departments , is responsible for ordering all steel plates and structurals.

Originally, Steel Purchasing was under the Vice President of Administration. However, because of their impact on production scheduling, steel storage, and handling, this section was transferred to the control of the Vice President in charge of Production.

## Production Planning

Production Planning is the first section to look at prospective jobs, and to aid management in determining future production schedules. When the proposed contract becomes a reality, the planners produce a detailed work outline for the yard. The hull is divided into units and sub-units (Figure #2). Locations for master butts and stock requirements are decided upon as well as the erection sequence. This information is then used to determine the master erection schedule (Figure #3) and the ground assembly schedule (Figure #4). The planners also prepare an outline of each Units' structure which is used by the steel section for detailing the unit books (Figure #5).

## Material (Steel) Section

Material Steel Section has complete control of steel plates and structural. Their first job is to screen the Hull Section's bill of material against yard stock. Grouping of odd size plates and structurals for economical storage is also implemented into the bill of material. Material yard arrival schedules, handling, identifying, storage, and delivery of steel are Material Section functions. Detailed information of pieces and storage location go into the unit book.

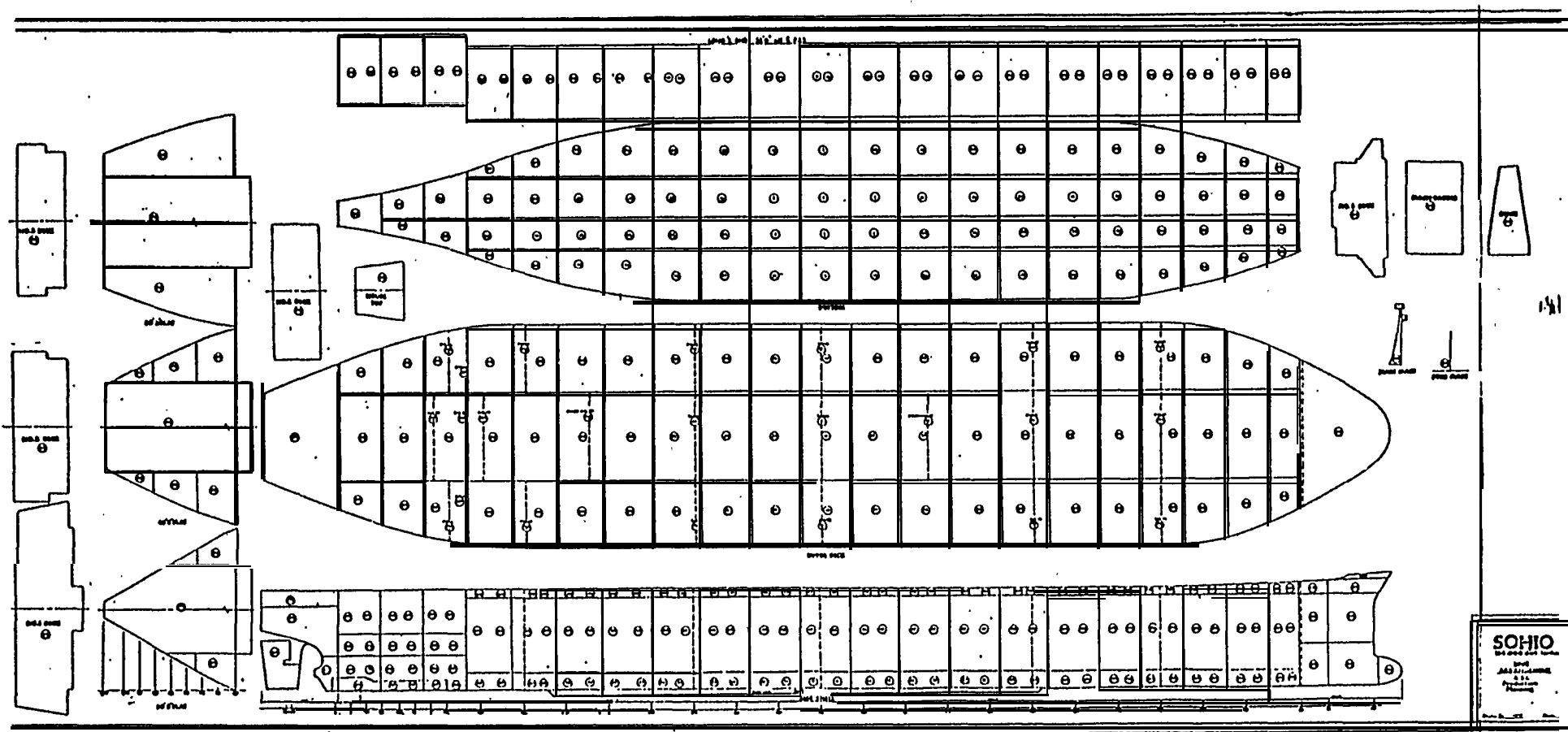


Figure 2.

LAY KEEL 7-12-76  
LAUNCH 6-11-77  
DELIVERY 10-18-77

# AVONDALE SHIPYARDS INC. MASTER ERECTION SCHEDULE

REVISIONS FAB  
INSTALL

ASI JOB C4-1620

SOHIO  
PIPING

ASI HULL NO.2295

1976-1977

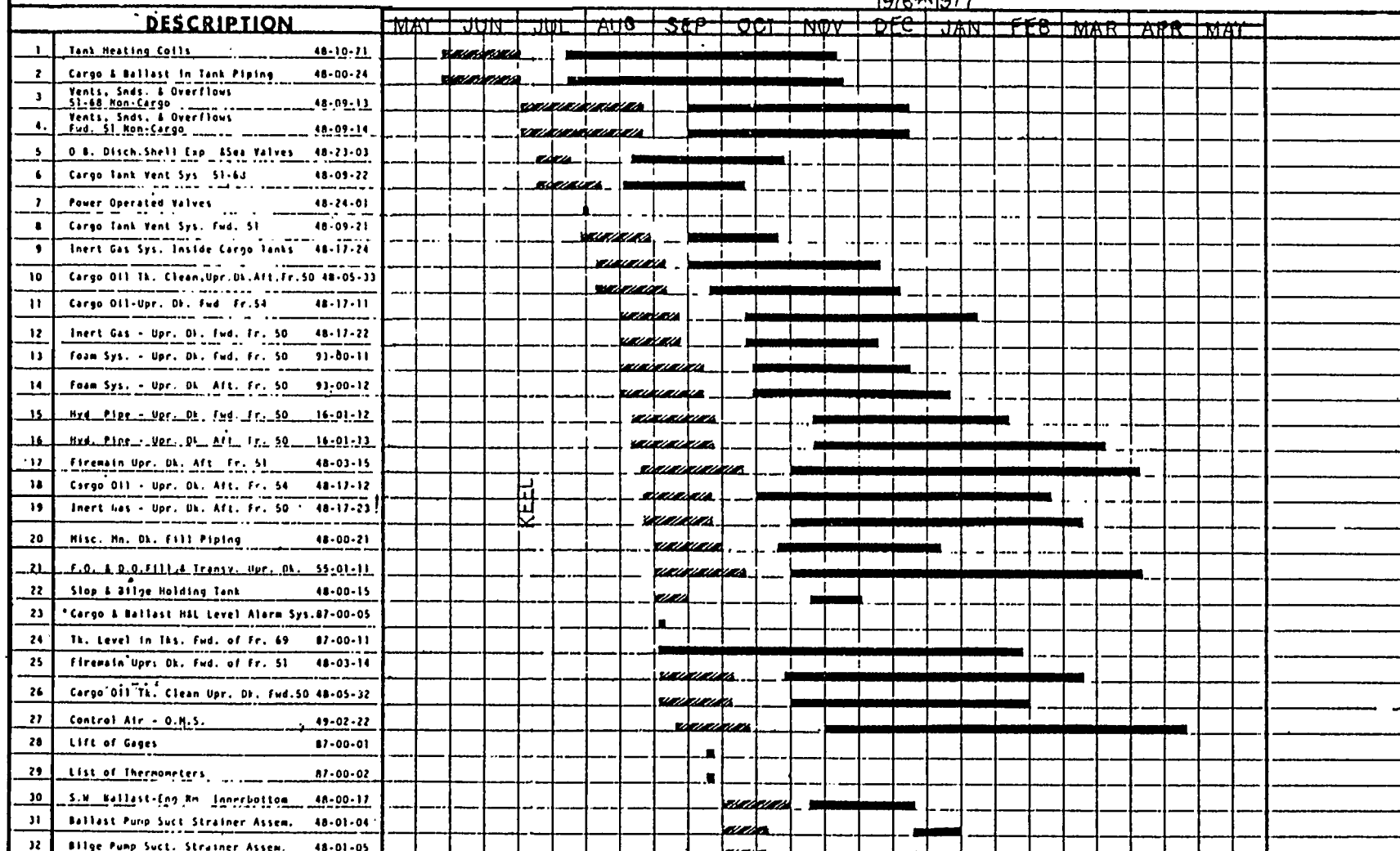


Figure 3.

105PRV

LAY KEEL 7-12-76  
 POS NO.1 7-12-76  
 POS NO.3 12-3-76  
 LOAD-OUT  
 LAUNCH 6-11-77

# GROUND ASSEMBLY SCHEDULE SOHIO C4-1620

## LEGEND

- START PRE-AS
- ▲ START SUB-ASSY
- START MN-ASSY
- ▲ BLAST & PANT
- ERECT

HULL 2295 SHT.1

DATE: 1-12-76

LAY KEEL

POS-2 1976-1977

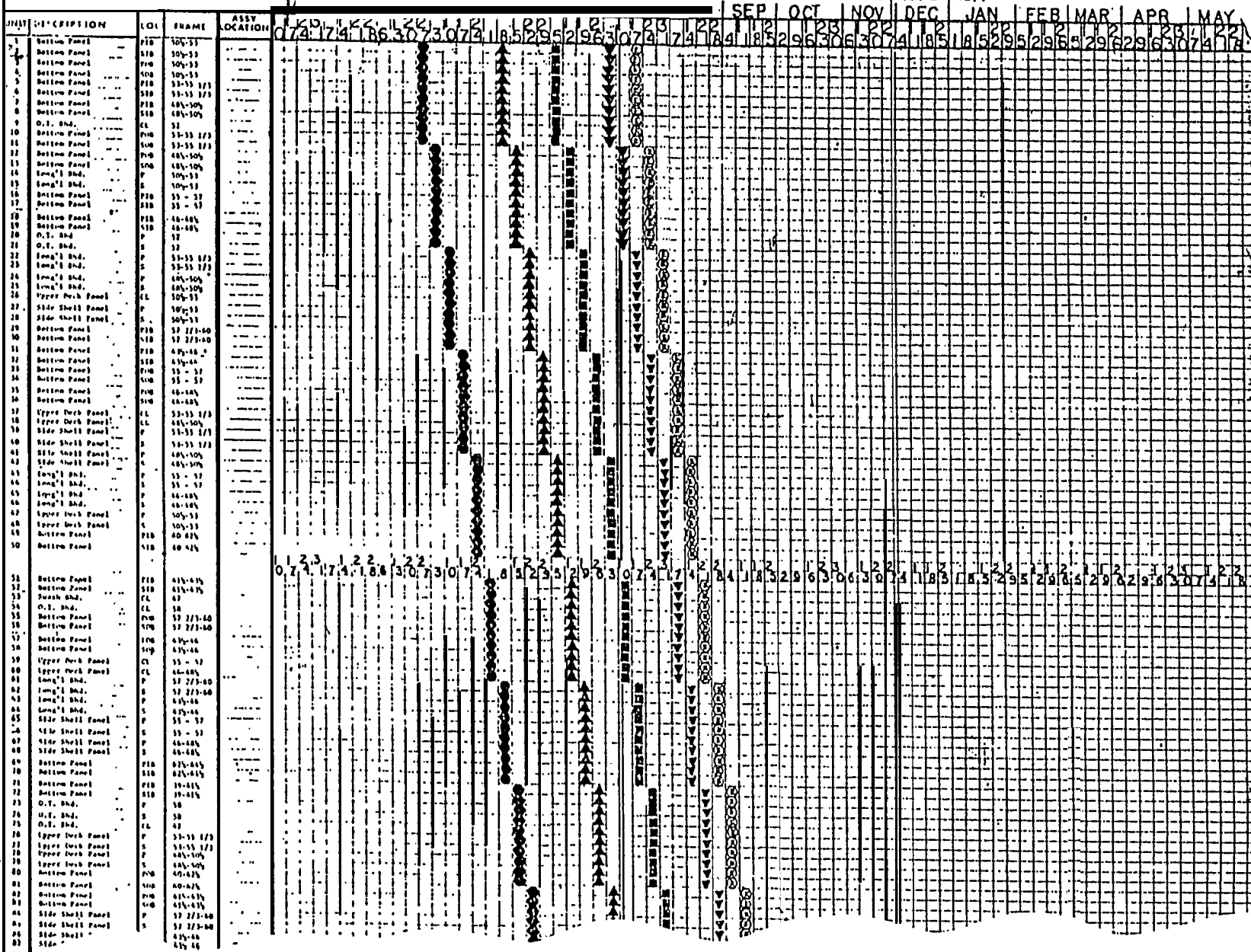


Figure 4.

HULL NO.		190 ASI		AVONDALE SHIPYARDS, INC.				UNIT NO. 127 Port 128 Stbd.			
ASSY AREA				PREFAB & ASSY. SHEET				SHEET NO. 18 OF 20			
JOB NO. C4-1620.				Outboard Bottom Panel Fr. 64 1/2 - 66 1/2				DWG. NO. 11-05-042 Ref.-1 11-05-04			
PIECE MARK	QUANTITY	DESCRIPTION		TYPE OF STEEL	DWG. DETAIL	LOFT INFO	STD. PC MK	REMARKS	WEIGHT		
									127-5	128-5	
		Transv. Rhd #66 Stringer#3		P/S							11
2   127-5-292	1	1	Pl. 5625 x 72" x 10' 0-3/8"	AL-36	10-A	610479			1347	1347	21
3   127-5-294	1	1	Pl. 5625 x 108" x 16' 0-11/32"	"	"	"			3465	3465	31
4   127-5-298	1	1	Pl. 5625 x 98" x 31' 0" App	"	"	610481			5809	5809	41
5   127-5-238	1	1	Pl. 5625 x 91" x 13' 0" App	"	"	610480			2262	2262	51
6   127-5-304	1	1	Pl. 5625 x 18" x 6' 6" App								
7   127-5-249											
8   127-5-253	1	1	Pl. 1. x 18" x 10' 1-1/8"	"	10a-11c	NT			618	618	81
11   127-5-290	1	1	Pl. 1 x 18" x 11' 6-9/16"	"	"	NT			95	95	111
12   127-5-291	1	1	Pl. 1 x 6" x 3' 1"	CR-A	Jim 601	Temp.			68	68	121
13   127-5-290	1	1	Pl. 5625 x 10" x 10' 1-1/4"	"	"	"			193	193	131
14   127-5-291	1	1	Pl. 5 x 6" x 5' 1-2/8"	"	"	11R			55	55	141
15   127-5-292	1	1	Pl. 5 x 6" x 3' 1"	"	"	"			34	34	151
16   127-5-292	1	1	Pl. 5 x 6" x 3' 1"	"	"	601			120	120	161
17   127-5-291	1	1	Pl. 5625 x 10" x 8' 10"	"	"	601	Servo		169	169	171
18   127-5-292	1	1	Pl. 5 x 6" x 3' 5"	"	"	11R	Temp.		35	35	181
19   127-5-290	1	1	Pl. 5 x 6" x 5' 5-3/8"	"	"	"			56	56	191
20											201
PIECE TOTAL				SHT. REV.				TOTAL WEIGHT	17186	17186	
										UNIT NO: 127 & 128-5 SHEET 18 OF 20	

Figure 5.

### NC Mold Loft

The NC loft manages and controls the data base for all jobs. Information is passed from the Scientific, Computer Applications , and Hull Sections to the NC loft for continual updating of the data base. Initial hullload and hullload maintenance are prepared by NC loft personnel. This is done in cooperation with the Hull and Scientific Sections.

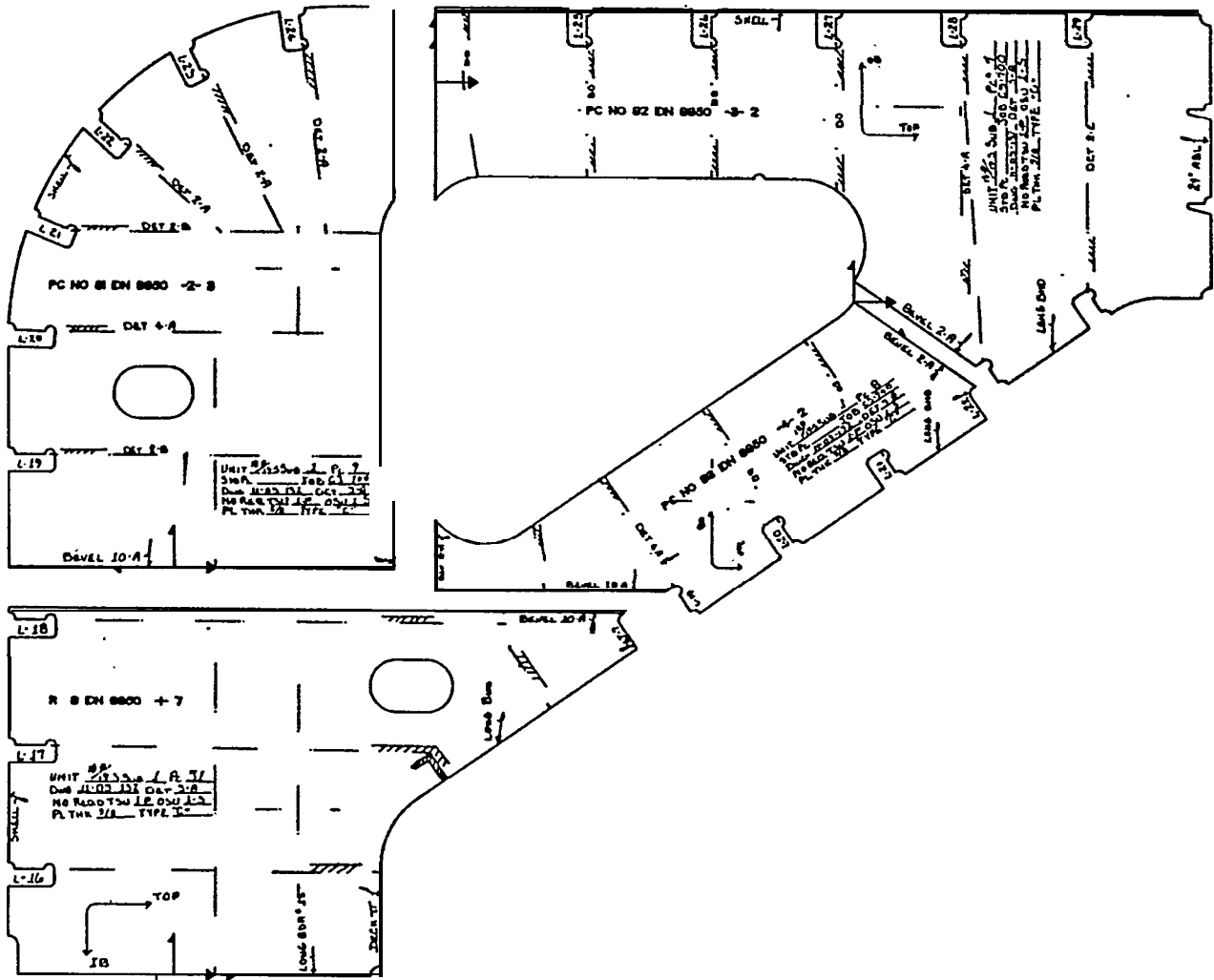
Part generation (Figure 6), nesting (Figure 7), frame-bending, and yard sketches are also functions of the NC loft. NC burning tapes and template information is completed in the unit books; this is done by the NC loft prior to the books' being sent back to Production for distribution.

NC loft equipment consists of a Kongsburg drafting machine and director, System 7, and IBM printer, and 4 IBM 2250 CRT Units tied to an IBM 2840;

Although the NC loft is-not responsible for- fairing, occasions have arisen where we have successfully faired a number of ships.

### Plate Shop

All the steel used in the yard is processed through the Plate Shop whose output capacity is 800 plates per week. Because the Plate Shop is located strategically between the steel storage and fabrication platens, material flow is automated (Figure 8) . A 17 ton capacity Via Nova crane automatically loads plates onto a conveyer system that leads into a Pangborn



+ TAPE NO. 109950 -11

Figure 6.



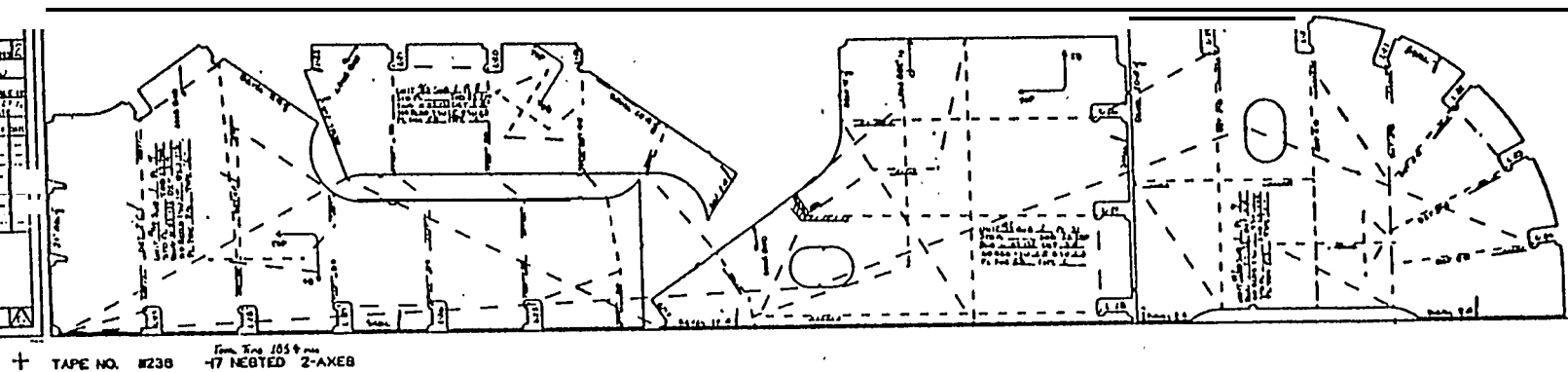


Figure 7.

327

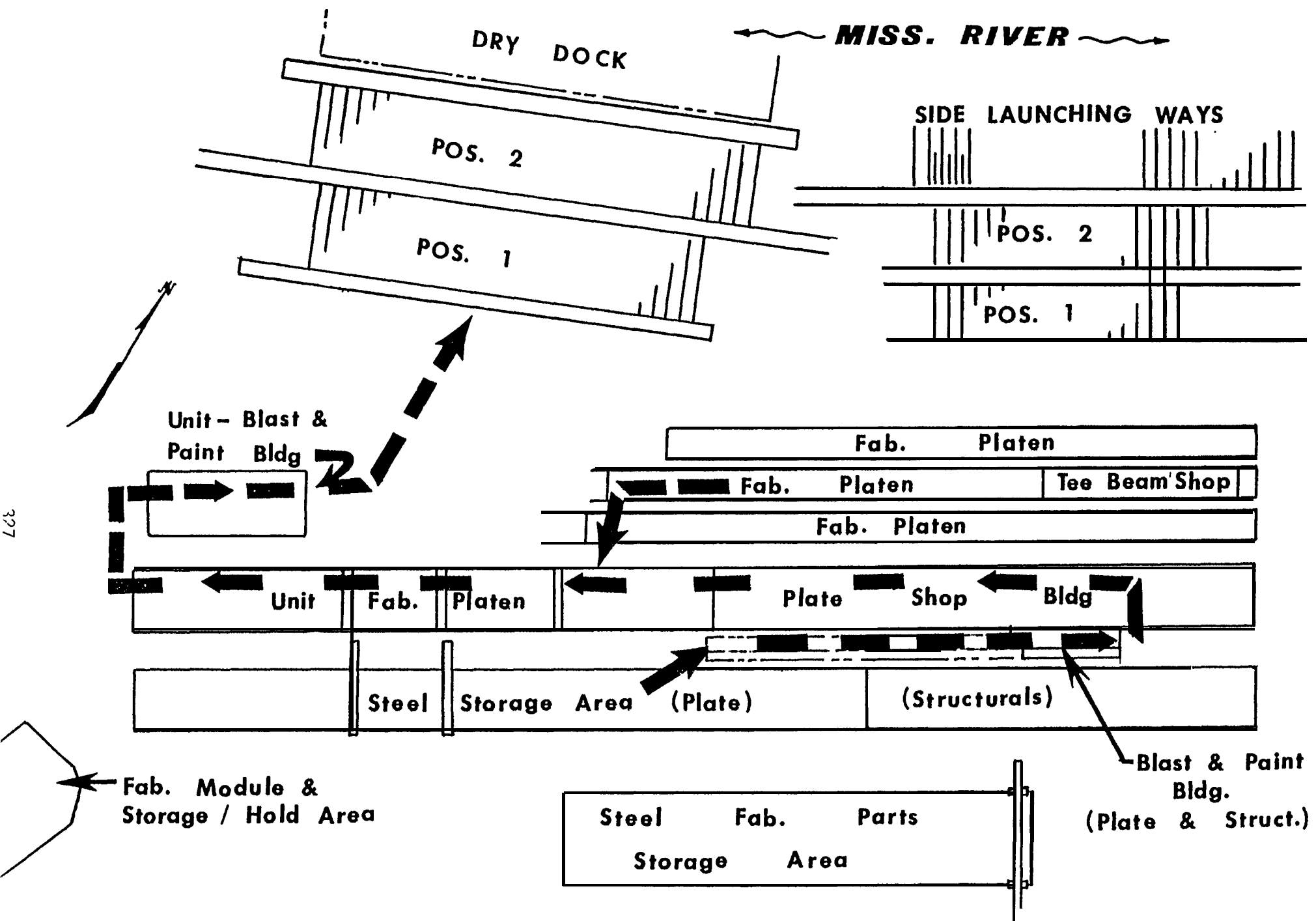


Figure 8.

shot blaster, and through a Binks paint booth. Structural are deflanged, if required, and processe'd through an adjacent automated system. Plates or structurals can be directed back to storage or onto the collator automatic stacking in the , Plate Shop. This system is controlled from a console located over the paint and blast booth. Two 17-1/2 ton Via Nova cranes then distribute. the plates to the appropriate machines. Figure #9 shows the layout of the Plate Shop.

Our NC burning equipment includes two Messer Greisheim and two C.R.O. (2 two axis and 2 three axis machines, with bevel capability) burning machines. each machine has eight burning heads (4 master torches and 4 slave torches). All of our NC burning machines are directed by Kongsburg directors linked with IBM System 7.

Paper tapes are kept as a means of emergency "back-up". Other burning equipment in our plate shop includes two C.R.O. flame planers and one servograph machine. The rest of our shop equipment is composed of presses, Rolls, shears, a newly installed panel line and a 700 ton Hugh Smith frame bender.

Adjacent to the plate shop is the pre-fabrication area and Tee beam manufacturing facility. Sub-units, girders, webs, etc. are moved from this site to the unit fabrication platens located at the end of the plate shop. Completed units then go through the snot blast and paint building to have the interiors finished. These units are. then transported by trailer or crane to a holding area or to the ship assembly area across the levee.

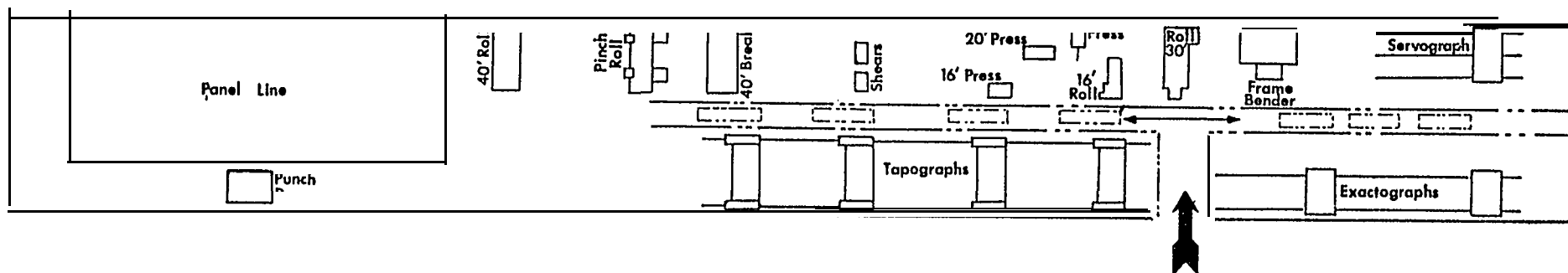


Figure 9.

What is the optimum organizational pattern in a shipyard? We. must conclude from our own NC experience that a precise answer to this question does not exist. Many things influence a shipyard's operation: management attitudes, personnel availability, finances, and geographical limitations are but a few. Without consideration for any of these factors, a good NC structure for a shipyard should be as follows:

A computer applications section to develop or procure the software necessary for a good NC program;

A fairing group, established in a department, that has the ability to manually fair a ship, and the adaptability to learn computer fairing;

A scientific section that uses the data base for hull calculation programs, and provides the basic information needed for fairing and hullload;

A hull engineering department, producing accurate drawings by utilizing the data base for drafting purposes, and supplying detailed information for fairing and hullload;

A hullload group comprised of engineering and NC loft people -- initial loading of the data base should be done by hull engineering, with the NC loft, taking responsibility for the maintenance of hullload when part generation begins.

An NC mold mold, under production management, whose duties include part generation and nesting programming, as well as data base control -- this group should have access to whatever equipment is necessary to accomplish their duties.

A review of the NC operations of several successful shipyards will be an effective method of determining a suitable NC system. Such a study will enable management to decide what hardware, software, and organizational pattern would best suit their needs.

THE APPLICATION OF NUMERICAL CONTROL SYSTEMS TO PLAN PRODUCTION  
OR  
N/C PART DEFINITION CAN MEAN PLANS TOO!

Albert P. Wickham  
and  
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Quincy Shipbuilding Division  
General Dynamics  
Quincy, Massachusetts

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Mr. Kucharski is a Senior Structural Designer with twelve years of hull structural design experience. He has worked as a hull and foundation designer at General Dynamics' Electric Boat Division and at Quincy and on assignment to Mare Island Naval Shipyard and Seatrain Shipbuilding, Inc.

## ABSTRACT

Parts definition language used to describe ships parts for N/C fabrication can also be used to assist the designer/draftsman in producing ship's plans. Expanded coding techniques developed by General Dynamics allow the efficient application of the AUTOKON Parts Program to provide the interface between the drafting function and the numerically controlled flat - bed plotter.



## BACKGROUND

The use of numerically controlled flame cutters to produce ships parts from steel plate is commonplace in U. S. shipbuilding today. In the majority of yards the data required to control these automated devices is produced by means of a system of computer programs. There are at least four such systems in use in the United States today: AUTOKON I, AUTOKON 71, SPADES and STEERBEAR. Each system provides the ability to store hull geometry data in an accessible data base and a system language to translate pictorial data, as shown on plans, into numerical data acceptable to the flame cutter's numerically controlled director. The individual parts are "coded" using the system language and processed by the computer to prepare N/C control data, usually on punched paper tape. In AUTOKON the **system** module performing this function is termed the Parts Program.

The vocabulary of each of the languages contains geometrical terms such as straight line, circle, tangent start point, direction length end point, etc., easily understood by every shipbuilder. By means of these terms, together with related numerical values such as coordinates and distances, geometrical shapes can be quantitatively defined. A straight line between **two points with coordinates  $x_1$ ,  $y_1$  and  $x_2, y_2$**  is described in AUTOKON as follows:

Start Point ( $x_1$   $y_1$ ) Straight Line: End Point ( $x_2, y_2$ ).

The languages also include features which simplify the coding effort such as provisions for recalling a series of repetitive steps, files for storing tabular data and FORTRAN-like commands to direct the processing sequence. In addition, the systems make provisions for macro programs, or subroutines, which represent a string of coding which performs some function or creates a geometric shape which will be re-used many times during the process of

coding parts for a vessel. These subroutines may be created, stored in the data base and recalled at will by the coder.

Errors in coding or computer processing are identified by using the pen of a numerically controlled plotter to simulate the torch path of the flame cutter. In this way the numerical data from the computer is reproduced in a form which can be visually verified.

### AUTOKON FOR DRAFTING

General Dynamics has been successfully fabricating ship parts from computer produced N/C flame cutting data since 1966. As our knowledge and experience in using the AUTOKON I system has increased over the past ten years, we have made significant changes to improve its efficiency and extend its range of application in our operations. One of the applications of AUTOKON I developed "and implemented at General Dynamics Quincy Shipbuilding Division is the use of the Parts Program to assist in the drafting and production of ship's plans.

The general approach has been to use the AUTOKON system language to describe the basic geometry contained in those views which comprise the plans to be produced for a ship. These views are then drawn on the numerically controlled plotter. This drawing then becomes the original of the plan and is given to the designer/draftsman to complete by the addition of views and details not coded, as well as dimensioning and annotation. The views prepared are primarily of ship structure and use information from the data base such as hull form geometry and the size and location of structural members.

## DRAFTING MACROS

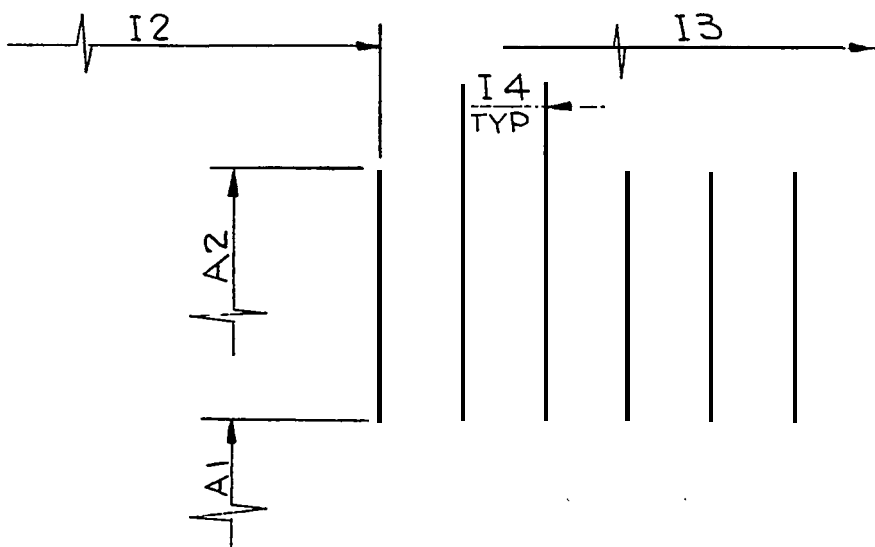
The application of an N/C system to plan production is based on the development of a series of macros devoted to performing certain repetitive drafting tasks. These macros were written as building blocks which condense any number of instructions into a one statement call and which include related entering parameters. The drafting macros were placed in the permanent system library within the data base and assigned a mnemonic title of “DRA” (draw).

DRA's are composed of vocabulary, stored AUTOKON routines and hull definition information from the data base. The ‘DO LOOP’ and testing (jump) capabilities of the parts program were heavily used. The following figures illustrate some of the basic DRA's developed.

Figure 1. DRA 300: DRA 300 draws a series of straight solid vertical lines. Five parameters were used. The first three, 12, 13 and 14 are the equivalent of FORTRAN “DO LOOP” indices. Each time the detail, in this case a straight line, is terminated **I2 is modified by I4 and the detail is repeated until  $I2 \geq I3$ . i.e.,** for DRA 300, 6-inch (14) is added to 6 feet (12) as long as the sum **is  $\leq$  12-feet 6-inches (I3).** The last two, **A1 and A2,** are arguments which provide numerical values for variable names used in the coding. i.e., for DRA 300 the number 6-feet is entered in A1 and 12-feet 6-inches for A2.

Figure 2. DRA 301: To draw straight solid horizontal lines, DRA 301 was added to the menu of macros. The logic of the entering arguments is similar to DRA 300.

Sketch



Parameters

I2 MIN DISTANCE IN X DIRECTION  
 I3 MAX DISTANCE IN X DIRECTION  
 I4 INCREMENTAL DISTANCE  
 A1 MIN DISTANCE IN Y DIRECTION  
 A2 MAX DISTANCE IN Y DIRECTION

Comments

EXAMPLE DRA 300,+6F,+12FGI,-6I(+6F+12FGI)  
 DRA 300,-6F,-12FGI,-6I(-6F-12FGI)

**AUTOKON**

Coded by  
 S. ENDRIS

Company  
 GD QUINCY

Date  
 8-14-72

Usage  
 DRAFTING

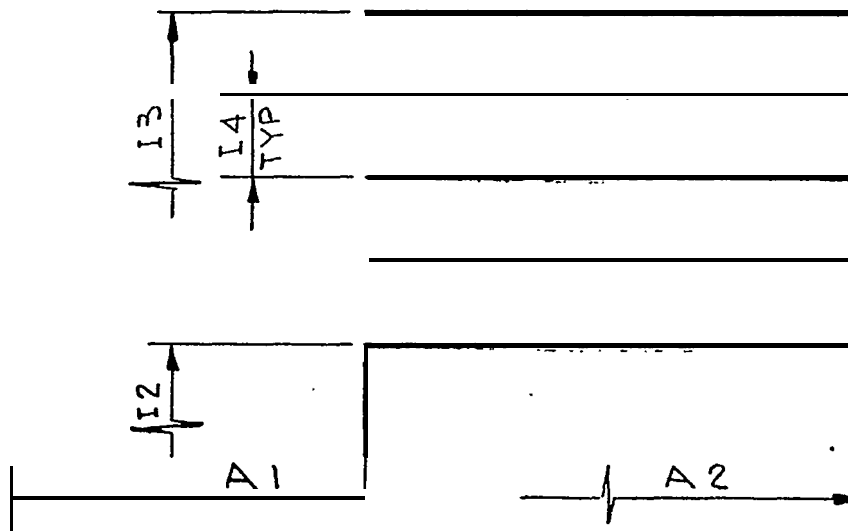
Distribution

DRA 300,I2,I3,I4(+A1+A2)

Q 6408

(ROUT 350)

FIG. 1



nwmW1

- I2 MIN DISTANCE IN Y DIRECTION
- I3 MAX DISTANCE IN V DIRECTION
- I4 INCREMENTAL DISTANCE
- A1 MIN DISTANCE IN X DIRECTION
- A2 MAX DISTANCE IN X DIRECTION

EXAMPLE DRA 301,+6F,+12F,+2F(+7F+8F)

DRA 301,I2,I3,I4(+A1+A2)

Q 6408

FIG. 2

(RCHT 351)

Figure 3. DRA 302 & DRA 305: DRA 302 and 305 create solid vertical and horizontal lines intersecting a frame contour called from the data base. The use of entering arguments is similar to the previous DRA s.

Figure 4. DRA 303 & DRA 306: DRA 303 and 306 generate a parallel at a distance A2 from a frame contour called from the data base and generate a series of solid vertical or horizontal lines from given points which terminate at the parallel contour.

Figure 5. DRA 325, DRA 326, DRA 327 and DRA 331: The solid line DRA's were recreated to provide dashed lines in place of the solid.

DRA 325 - Dashed vertical lines

DRA 326 - Dashed horizontal lines

DRA 327 - Dashed vertical lines intersecting a frame contour

DRA 331 - Dashed horizontal line intersecting a parallel to a frame contour

Figure 6. DRA 350, DRA 351, DRA 352 and DRA 354: The previous series is repeated for the line pattern which traditionally represents bulkheads intersecting the far side of the plate viewed. The arguments now include a parameter for the thickness of the line. Thicknesses appropriate for various scales are listed. The sign of this argument acts as a flag to test the location of the molded line, i. e., in DRA 350 + A3 places the ML to the right - A3 places the ML to the left.

Figure 7. DRA 375, DRA 376, DRA 377 and DRA 379: The series is again repeated using the symbols for butt and seam lines.

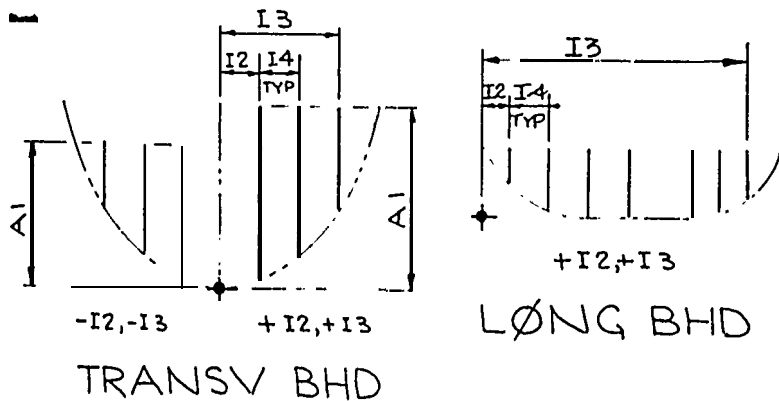
The various line types are arranged in a numbered series.

DRA 300 to 324 Solid Line

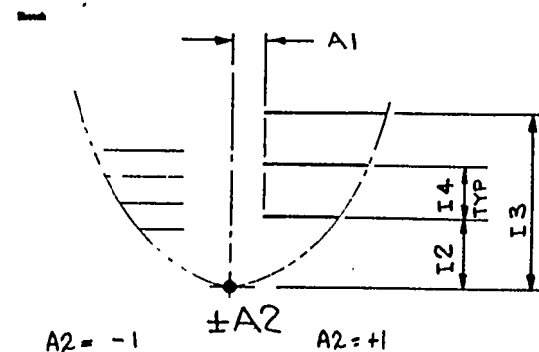
DRA 325 to 349 Dashed Line

DRA 350 to 375 Bulkhead - Far Side

DRA 375 to 399 Butts and Seams



Parameters  
 I2 MIN DISTANCE IN X DIRECTION  
 I3 MAX DISTANCE IN X DIRECTION  
 I4 INCREMENTAL DISTANCE  
 A1 HEIGHT ABV  $\Phi$



Parameters  
 LKG FWD  
 I2 MIN DISTANCE IN Y DIRECTION  
 I3 MAX DISTANCE IN Y DIRECTION  
 I4 INCREMENTAL DISTANCE  
 A1 DISTANCE  $\Phi$ FF  $\Phi$   
 A2  $\pm 1, -1$

EXAMPLE DRA 302,+GF,+18F,+6F(+27F)  
 DRA 302,-GF,-18F,+6F(+20F)

**AUTOKON** S. ENDRIS G. QUINCY  
 DRAFTING  
 Distribution DRA 302,I2,I3,I4(+A1)

Q 6408

(ROUT 346)

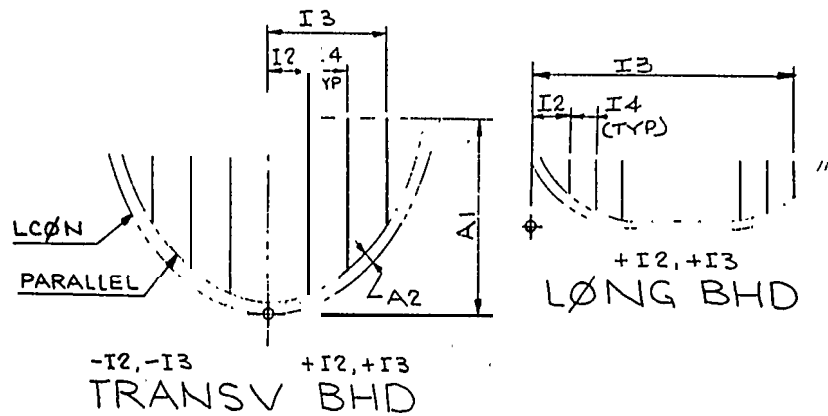
EXAMPLE DRA 305,+20F,+40F,+10F(+6F+1)  
 DRA 305,+18F,+30F,+6F(-8F-1)

**AUTOKON** S. ENDRIS G. QUINCY 8-15-12  
 Distribution DRA 305,I2,I3,I4(+A1  $\pm$  A2)

Q 6408

(ROUT 347,368)

FIG. 3



Parameters  
 I2 MIN DISTANCE IN X DIRECTION  
 I3 MAX DISTANCE IN X DIRECTION  
 I4 INCREMENTAL DISTANCE  
 A1 HEIGHT ABV  $\phi$   
 A2 DISTANCE TO PARALLEL

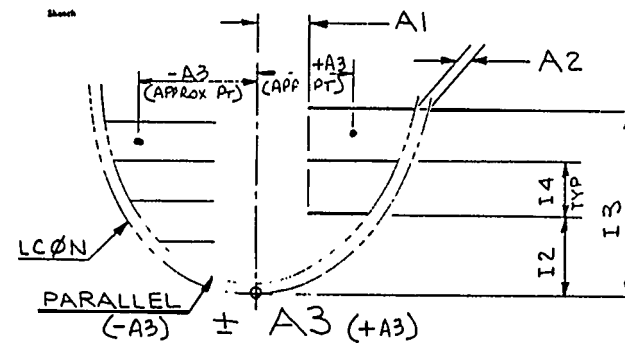
Comments

EXAMPLE DRA 303,+6F,+18F,+6F(+27F+18I)  
 DRA 303,-6F,-18F,+6F(+27F+2F)

AUTOKON	Control by	Company	Date
	S. ENDRISS	G.D. QUINCY	8-15-72
Usage DRAFTING			
Distribution	DRA 303,I2,I3,I4 (+A1+A2)		

Q 6408

(ROUT 306, 378)



Parameters  
 I2 MIN DISTANCE IN Y DIRECTION  
 I3 MAX DISTANCE IN Y DIRECTION  
 I4 INCREMENTAL DISTANCE  
 A1 DISTANCE OFF  $\phi$   
 A2 DISTANCE TO PARALLEL  
 A3 '+ CORN. DISTANCE' OR '-' CORN. DISTANCE

Comments

EXAMPLE DRA 306,+10F,+30F,+15F(+16F+2F+1)  
 DRA 306,+8F,+23I,+15I(-15F+18I-2BI)

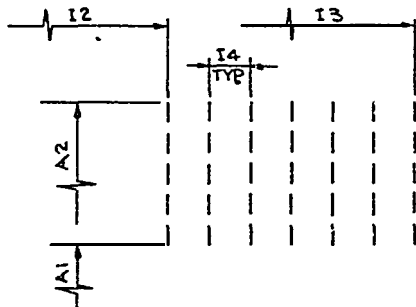
AUTOKON	Control by	Company	Date
	S. ENDRISS	G.D. QUINCY	8-15-72
Usage DRAFTING			
Distribution	DRA 306,I2,I3,I4 (+A1+A2+A3)		

Q 6408

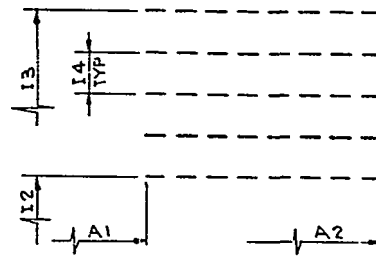
(ROUT 374)

FIG. 4





- I2 MIN DISTANCE IN X DIRECTION
- I3 MAX DISTANCE IN X DIRECTION
- I4 INCREMENTAL DISTANCE
- A1 MIN DISTANCE IN Y DIRECTION
- A2 MAX DISTANCE IN Y DIRECTION



- I2 MIN DISTANCE IN Y DIRECTION
- I3 MAX DISTANCE IN Y DIRECTION
- I4 INCREMENTAL DISTANCE
- A1 MIN DISTANCE IN X DIRECTION
- A2 MAX DISTANCE IN X DIRECTION

EXAMPLE DRA 325, +GF, +12FGI, +GI (+GF + 12FGI)  
DRA 325, -GF, -12FGI, -GI (-GF - 12FGI)

<b>AUTOKON</b>	Drawn by	S. ENDRIS	Checked by	G. QUINCY	Date	8-15-72
	DRAFTING					
DRA 325, I2, I3, I4 (+A1 + A2)						

Q 4408

(ROUT 352)

EXAMPLE DRA 326, +GF, +12F, +2F (+7F + 8F)

<b>AUTOKON</b>	Drawn by	S. ENDRIS	Checked by	G. QUINCY	Date	8-15-72
	DRAFTING					
DRA 326, I2, I3, I4 (+A1 + A2)						

Q 4408

(ROUT 353)

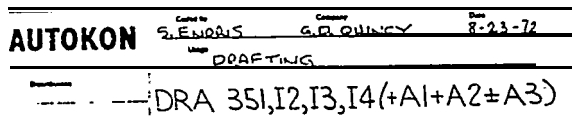
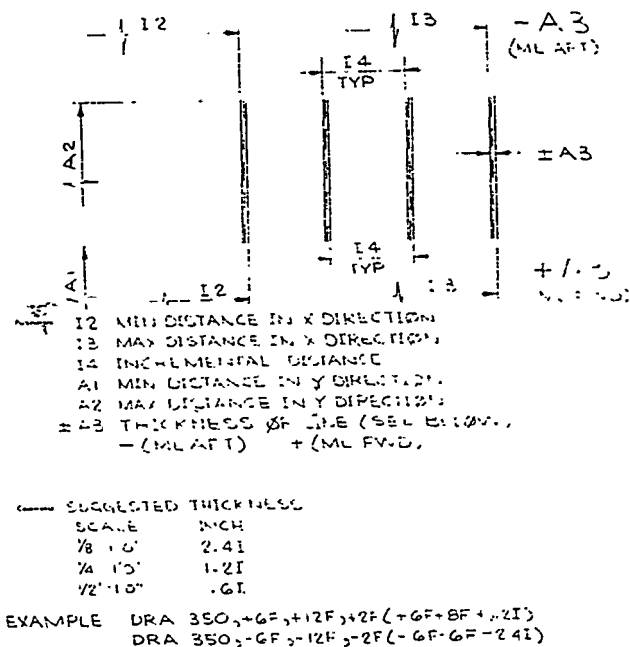
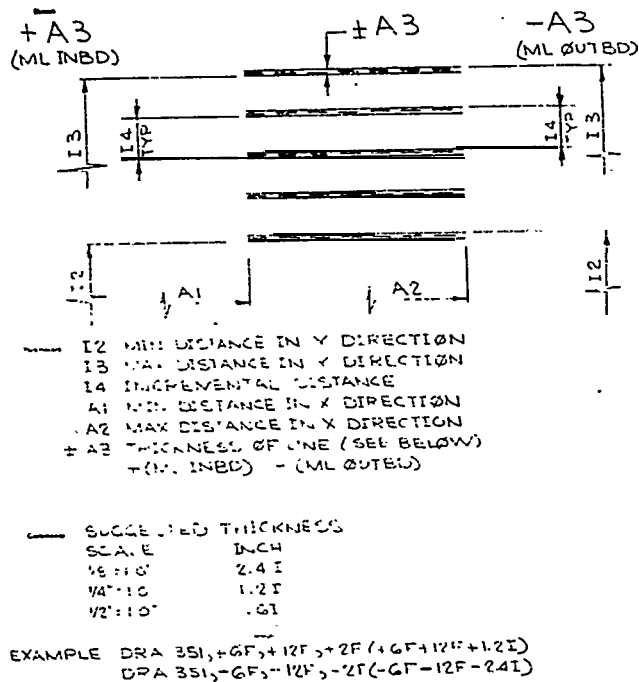
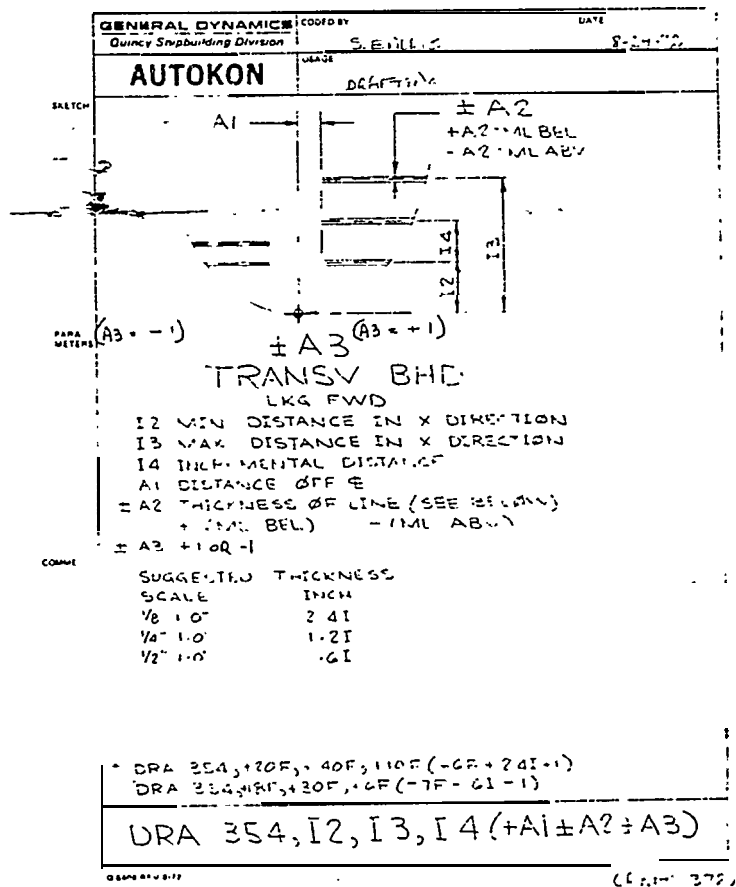
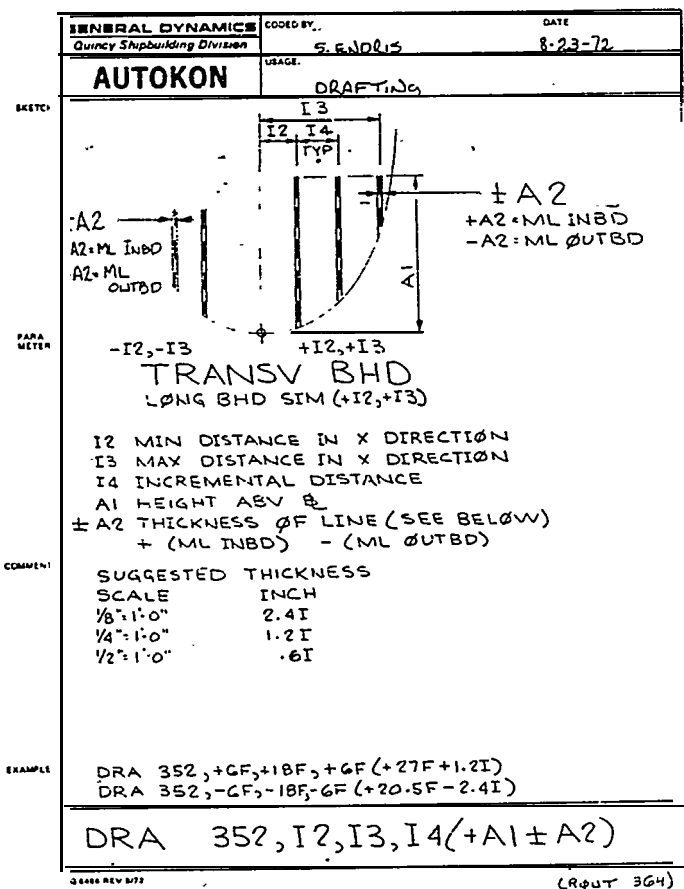
<b>GENERAL DYNAMICS</b> Quincy Shipbuilding Division		Drawn by	S. ENDRIS	Checked by		Date	8-19-72
<b>AUTOKON</b>		DRAFTING					
SKETCH							
APP. METERS	<p>TRANSV BHD LKG FWD</p> <p>I2 MIN DISTANCE IN Y DIRECTION I3 MAX DISTANCE IN Y DIRECTION I4 INCREMENTAL DISTANCE A1 DISTANCE OFF C A2 DISTANCE TO PARALLEL A3 "+ APPROX COOR." "- APPROX COORDINATE"</p>						
EXAMPLES	<p>DRA 331, +10F, +30F, +10F (+10F + 27F) DRA 331, +8F, +23F, -51 (-15F + 181 - 1)</p> <p>DRA 331, I2, I3, I4 (+A1 + A2 ± A3)</p>						

<b>GENERAL DYNAMICS</b> Quincy Shipbuilding Division		Drawn by	S. ENDRIS	Checked by		Date	8-15-72
<b>AUTOKON</b>		DRAFTING					
SKETCH							
APP. METERS	<p>LONG BHD</p> <p>I2 MIN DISTANCE IN X DIRECTION I3 MAX DISTANCE IN X DIRECTION I4 INCREMENTAL DISTANCE A1 HEIGHT ABV</p>						
EXAMPLES	<p>DRA 327, +GF, +18F, +GF (+27F) DRA 327, -GF, -18F, +GF (+20F)</p> <p>DRA 327, I2, I3, I4 (+A1)</p>						

Q 4408 REV 0/12

(ROUT 348)

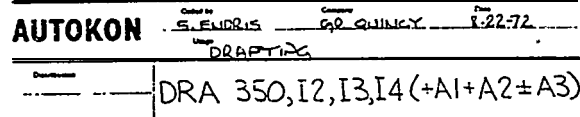
FIG. 5



344

(ROUT 373)

Q 6408



(ROUT 383)

Q 6408

FIG. 6

GENERAL DYNAMICS		CODED BY:	DATE
Guincy Shipbuilding Division		S. ENDRIS	9-7-72
AUTOKON		USAGE:	DRAFTING

TRANSV BHD

12 MIN DISTANCE IN X DIRECTION  
 I3 MAX DISTANCE IN X DIRECTION  
 I4 INCREMENTAL DISTANCE  
 A1 DISTANCE OFF C (±)  
 A2 DISTANCE TO SYMBOL  
 ±A3 ±1 OR -1

EXAMPLE  
 DRA 379, +30F, +50F, +10F (+7F + 3F + 1)  
 DRA 379, +25F, +32F, +7F (+12F + 12F - 1)

DRA 379, I2, I3, I4 (±A1 + A2 ± A3)

GENERAL DYNAMICS		CODED BY:	DATE
Guincy Shipbuilding Division		S. ENDRIS	9-6-72
AUTOKON		USAGE:	DRAFTING

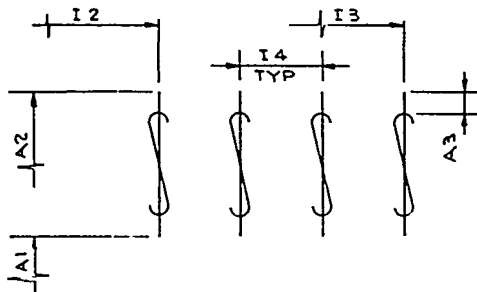
TRANSV BHD  
 LONG BHD SIM (+I2 + I3)

I2 MIN DISTANCE IN X DIRECTION  
 I3 MAX DISTANCE IN X DIRECTION  
 I4 INCREMENTAL DISTANCE  
 A1 HEIGHT ABV C  
 A2 DISTANCE TO SYMBOL

EXAMPLE  
 DRA 377, +10F, +18F, +8F (+36F + 4F)  
 DRA 377, -12F, -18F, -6F (+30F + 3F)

DRA 377, I2, I3, I4 (+A1 + A2)

(R057 356)



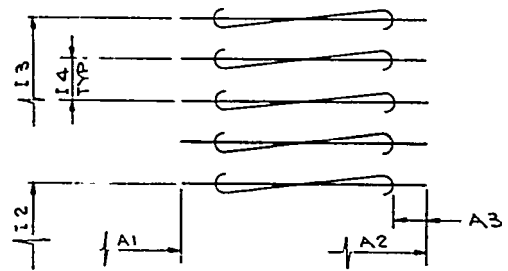
12 MIN DISTANCE IN X DIRECTION  
 I3 MAX DISTANCE IN X DIRECTION  
 I4 INCREMENTAL DISTANCE  
 A1 MIN DISTANCE IN Y DIRECTION  
 A2 MAX DISTANCE IN Y DIRECTION  
 A3 DISTANCE TO BUTT SYMBOL

EXAMPLE DRA 375, +6F, +12F, +3F (+6F + 12F + 9F)  
 DRA 375, -6F, -12F, -3F (-6F - 12F - 9F)

AUTOKON		CODED BY:	DATE
S. ENDRIS		GP QUINCY	9-5-72
DRAFTING			

DRA 375, I2, I3, I4 (+A1 + A2 + A3)

Q 6408



12 MIN DISTANCE IN Y DIRECTION  
 I3 MAX DISTANCE IN Y DIRECTION  
 I4 INCREMENTAL DISTANCE  
 A1 MIN DISTANCE IN X DIRECTION  
 A2 MAX DISTANCE IN X DIRECTION  
 A3 DISTANCE TO BUTT SYMBOL

EXAMPLE DRA 376, +6F, +12F, +2F (+6F + 12F + 1F)  
 DRA 376, -6F, -12F, -2F (-6F - 12F - 1F)

AUTOKON		CODED BY:	DATE
S. ENDRIS		GP QUINCY	9-5-72
DRAFTING			

DRA 376, I2, I3, I4 (+A1 + A2 + A3)

Q 6408

FIG 7

Figure 8. DRA 312: DRA 312 is typical of another solid line DRA. In this macro a parallel to a frame contour is generated to simulate a web frame.

A1 - represents the depth of a web frame.

A2 and A4 - approximate values which place the parallel in the proper quadrant.

A3 and A5 - actual deck heights.

Figure 9. DRA 401: This DRA was developed to draw a series of angles representing stiffeners under a deck or on a longitudinal bulkhead. A “DO LOOP” is again used to define the start and end of the series of angles.

A1 and A2 - set a new origin.

A3 - rotates the axis of the draw and allows the series of stiffeners to be drawn at any angle.

A4 thru A6 - arguments for the sizes of the stiffeners.

Figure 10. DRA 404: DRA 404 is similar to 401 but draws Tee stiffeners. -

“Figure 11. DRA 412 and 413: DRA 412 and 413 will draw a series of access openings or lightening holes either horizontally or vertically.

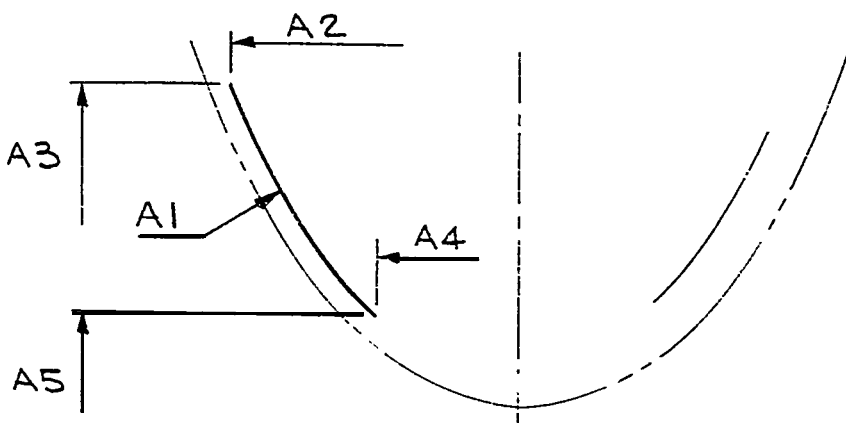
The DRA’s described above represent the fundamental building blocks of the method. These basic DRA’s may be used independently within the coding language or may be boot-strapped into more elaborate macros.

Figure 12. DRA 654: This DR represents the basic configuration of a typical Quincy LNG Tanker bow web frame. It was coded using the

<b>GENERAL DYNAMICS</b> <i>Quincy Shipbuilding Division</i>	CODED BY: <b>RV/ KUCHARSKI</b>	DATE <b>2-26-73</b>
<b>AUTOKON</b>	USAGE: <b>DRAFTING</b>	

SKETCH



PARAMETERS

A1 DISTANCE TO PARALLEL  
 A2 APPROXIMATE X COORDINATE  
 A3 ACTUAL Y COORDINATE  
 A4 APPROXIMATE X COORDINATE  
 A5 ACTUAL Y COORDINATE

COMMENT

EXAMPLES

DRA 312 (+1F-60F+50F-30F+20F)  
 DRA 312 (+2F+60F+50F+30F+20F)

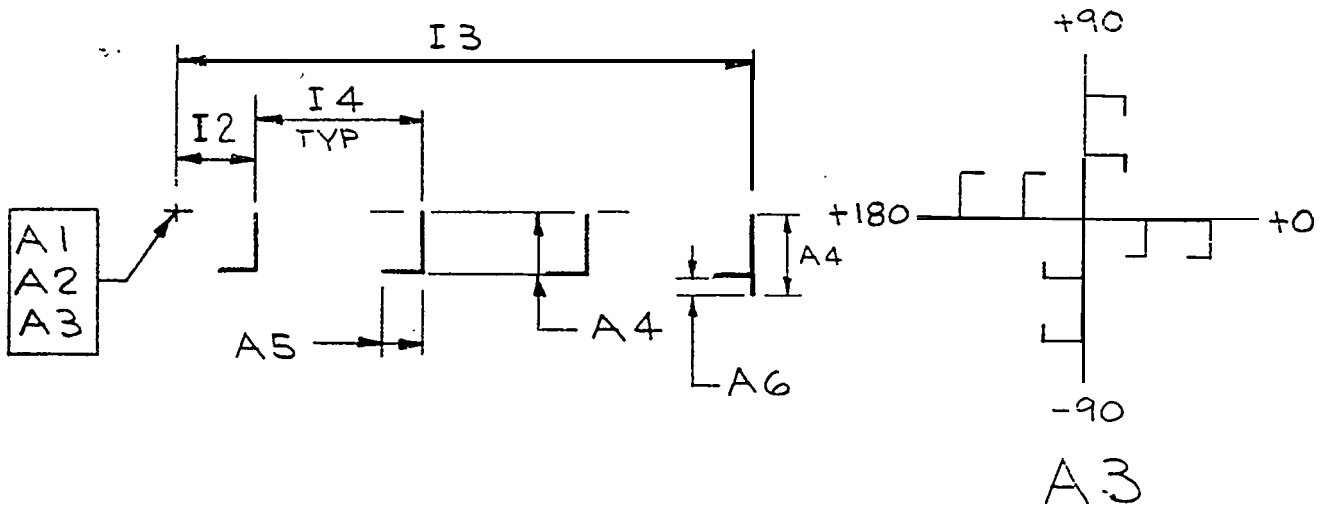
  

DRA 312(±A1±A2+A3±A4+A5)

Q 6408 RFV 8/72

FIG. 8

Sketch



Parameters

- I2 DISTANCE TO FIRST STIFFENER
- I3 DISTANCE TO LAST STIFFENER
- I4 INCREMENTAL DISTANCE
- A1 X COORDINATE
- A2 Y COORDINATE
- A3 DIRECTION
- A4 DEPTH OF WEB
- A5 WIDTH OF FLANGE
- A6 DISTANCE TO FLANGE

Comments

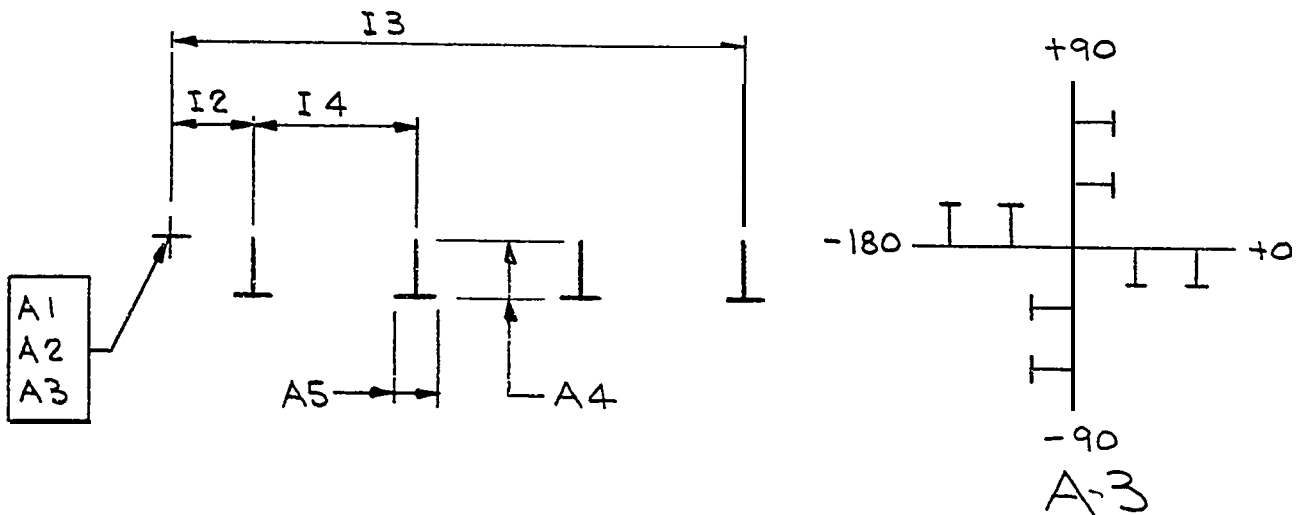
EXAMPLE DRA 401,+0,+6F,+2F(+7F+14F-90+6I+4I-0)  
 DRA 401,+2F,+6F,+2F(+7F+14F+180+6I+4I+16)

AUTOKON	Coded by	Company	Date
	S. ENDRIS	GD QUINCY	9-6-72
	Usage	DRAFTING	
Distribution	DRA 401,I2,I3,I4(+A1---+A6)		

Q 6408

FIG. 9

Sketch



Parameters  
 I2 DISTANCE TO FIRST STIFFENER  
 I3 DISTANCE TO LAST STIFFENER  
 I4 INCREMENTAL DISTANCE  
 A1 X COORDINATE  
 A2 Y COORDINATE  
 A3 DIRECTION  
 A4 DEPTH OF WEB  
 A5 WIDTH OF FLANGE

Comments

EXAMPLE DRA 404,+0,+6F,+2F(+7F+14F-90+6I+4I)  
 DRA 404,+2F,+6F,+2F(+7F+14F+90+6I+4I)

<b>AUTOKON</b>	Coded by	Company	Date
	S. ENDRIS	GD QUINCY	9-6-72
	Usage	DRAFTING	
Distribution	DRA 404,I2,I3,I4(+A1---+A5)		

Q 6408

FIG. 10

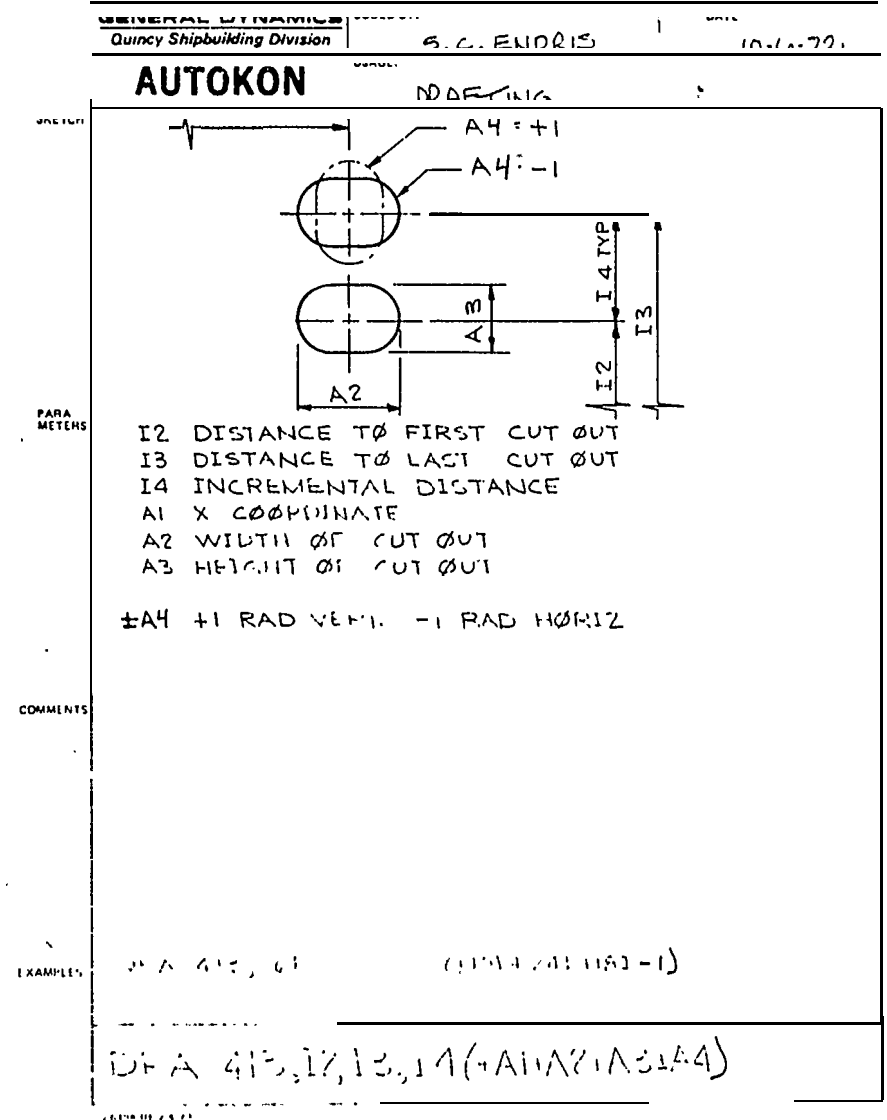
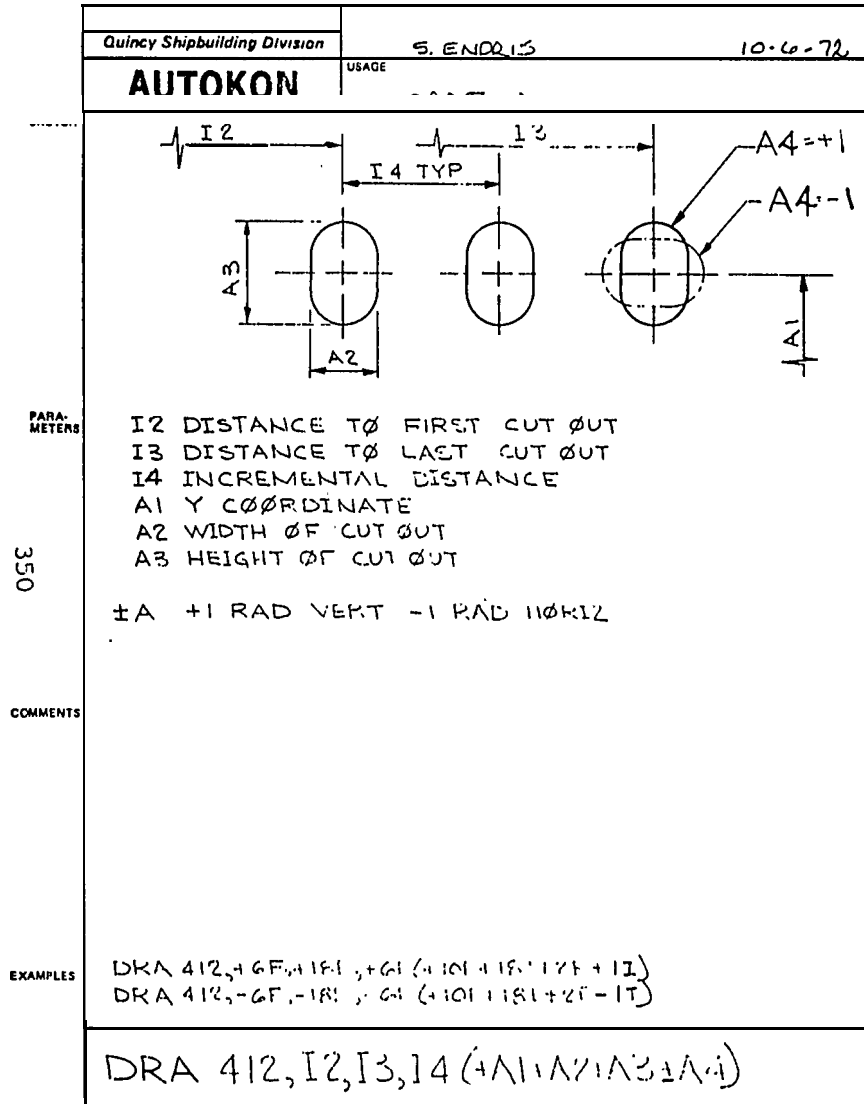


FIG. 11

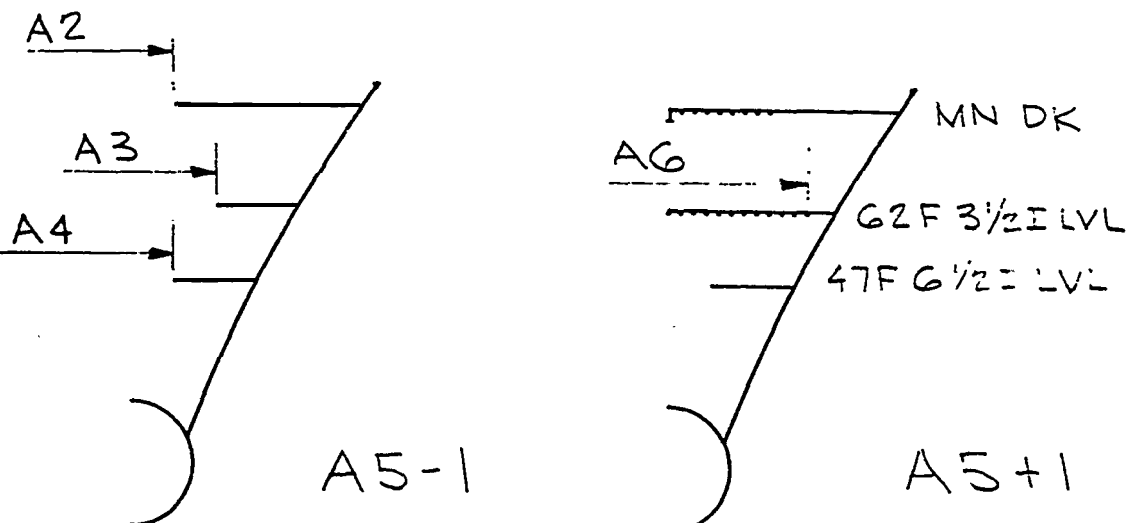


AUTOKON

USAGE:

DRAFTING

SKETCH



PARAMETER

A1 = FR NØ

- A1 FR NØ
- A2 DIST TO MN DK
- A3 DIST TO 62F 3 1/2 I LVL
- A4 DIST TO 47F 6 1/2 I LVL
- A5 -1 WITHOUT DECK STIFFS  
+1 WITH DECK STIFFS
- A6 DIST TO LAST STIFF

COMMENT

EXAMPLES

DRA 654 (+125 + 50I + 100I + 50I - 1)  
DRA 654 (+125 + + + +1 + 523I)

DRA 654 (+A1 + A2 + A3 + A4 ± A5 + A6)

system language and makes several calls of basic drafting (DRA) macros. The deck heights are constant and included in the coding.

A1 - identifies the specific frame to be retrieved from the database.  
A2, A3 and A4 - are the distances from the ship's centerline to the decks or flats.

A5 - a flag to indicate if underdeck stiffeners are to be included as part of the drawing.

A6 - the distance to the most outboard stiffener on the flat located 62 ft. above baseline. This value is omitted when stiffeners are not indicated. This DRA is the first macro called when coding each of the five specific web frames of this type in the LNG bow section.

### APPLICATION OF DRA'S

Drafting macros, together with other subroutines and stored ship hull geometry, provide the capability of describing large amounts of graphic data which can be stored in the data base and drawn by an N/C plotter.

Figure 13. Web Frame 133: The figure contains a listing of the manuscript and the resulting drawing of a major structural system of the LNG tankers now being constructed at Quincy. An explanation of the coding follows:

<u>Line/s</u>	<u>Remarks</u>
1	Identification number
2-3	Various program options
4-6	General comments
7	Startpoint: This will establish an "X-Y" coordinate system about the ships base line, center line. A COMM statement provides manuscript annotation.

1. PC 1021330  
 2. \$A1.0  
 3. \$K1.0  
 4. COMM (RWK LUG TRANSV WEB FR 133 STD SIDE LUG FWD  
 5. THIS PROGRAM OFVERIFIED FROM PLAN 401-211-12  
 6. REV C ON 10/10/73)  
 7. SPT  
 8. DRA 554 (+133+++1+300) COMM (BL/CL)  
 9. DRA 434,265116 ,2671 ,7F (+192F+25112+12116)  
 10. DRA 401,2951 ,4441 ,29.51(+192F+61+41+)  
 11. H1=(+192F-25112+1)  
 12. DRA 306,81 ,=(H1+11),24 (-61+181+400)  
 13. DRA 305,22F9116 ,3212146,24 (+11)  
 14. COMM (FR WEB  
 15. DRA 312 (+31114+4001+H1+2671+62F3140)  
 16. DRA 312 (+31114+4001+H1+2671+62F3140)  
 17. ROUT 339(+21F4110)  
 18. CIR:CTR (+12F) RAD (-9F4118)  
 19. CPT (+2F7114)  
 20. ROUT 339(+2F4114)  
 21. C R:CTR (+12F) RAD (+9F3118)  
 22. CPT (+21F3114)  
 23. H2=(29.51) COMM (STIFF SP)  
 24. COMM (BHD STIFFS)  
 25. DRA 300,0 ,301 ,82 (+24F+62F3116)  
 26. DRA 300,531 ,601 ,82 (+23F61+52F3115)  
 27. DRA 300,98.5 ,901 ,52 (+22F21+62F3116)  
 28. DRA 303,1191 ,1951 ,82 (+62F3116+151)  
 29. COMM (AD)  
 30. H3=(+62F3116-29.51) H4=(+62F3116-99.51)  
 31. H5=(+62F3116-147.51) H6=(+47F6116-29.51)  
 32. H7=(+47F6116-44.51) H8=(+47F6116-147.51)  
 33. H9=(+32F3116-29.51) H10=(+591+14.751)  
 34. DRA 412,810 ,2351 ,82 (+83+181+301+1)  
 35. DRA 412,810 ,2361 ,82 (+1.4+181+301+1)  
 36. DRA 412,810 ,2061 ,82 (+85+181+301+1)  
 37. DRA 412,810 ,1771 ,52 (+86+181+301+1)  
 38. DRA 412,810 ,1471 ,82 (+87+181+301+1)  
 39. DRA 412,810 ,1471 ,82 (+88+181+301+1)  
 40. DRA 412,810 ,1131 ,82 (+89+181+301+1)  
 41. COMM (STANCHIONS)  
 42. DRA 350,612 ,71 ,7F (+88150+124F-31146)+1214)  
 43. DRA 350,61 ,71 ,7F (+62F3140+H1+121)  
 44. DRA 350,271116 ,2721 ,7F (+62F3140+H1+121)  
 45. DRA 346 (+182F+86F)  
 46. COMM (DK BUTTS)  
 47. DRA 382,44,251 ,3991 ,88.51(+192F3124+61)  
 48. DRA 382,44,251 ,2221 ,88.51(+192F3140+61)  
 49. OFF CT SL:EP1 ON CT  
 50. CN PAUSE  
 51. TEXT ,+5F ,+6F ,+1F(TRANSV NT BHD / WEB FR 133  
 52. TEXT ,+13F91 ,+7F61 ,+51(STD SIDE LUG FWD)  
 53. TEXT ,+61 ,+87F ,+61(CL OF SHIP)  
 54. ESS1 (.3. RWK SPTLL PC 1021330 .4.)  
 55. SCALF(.312495  
 56. FIN  
 57. #  
 MANUS 0 1021 0 LINE 0 COMM 101  
 MANUS 1 1021 \*\*\* LINE 57 COMM 101

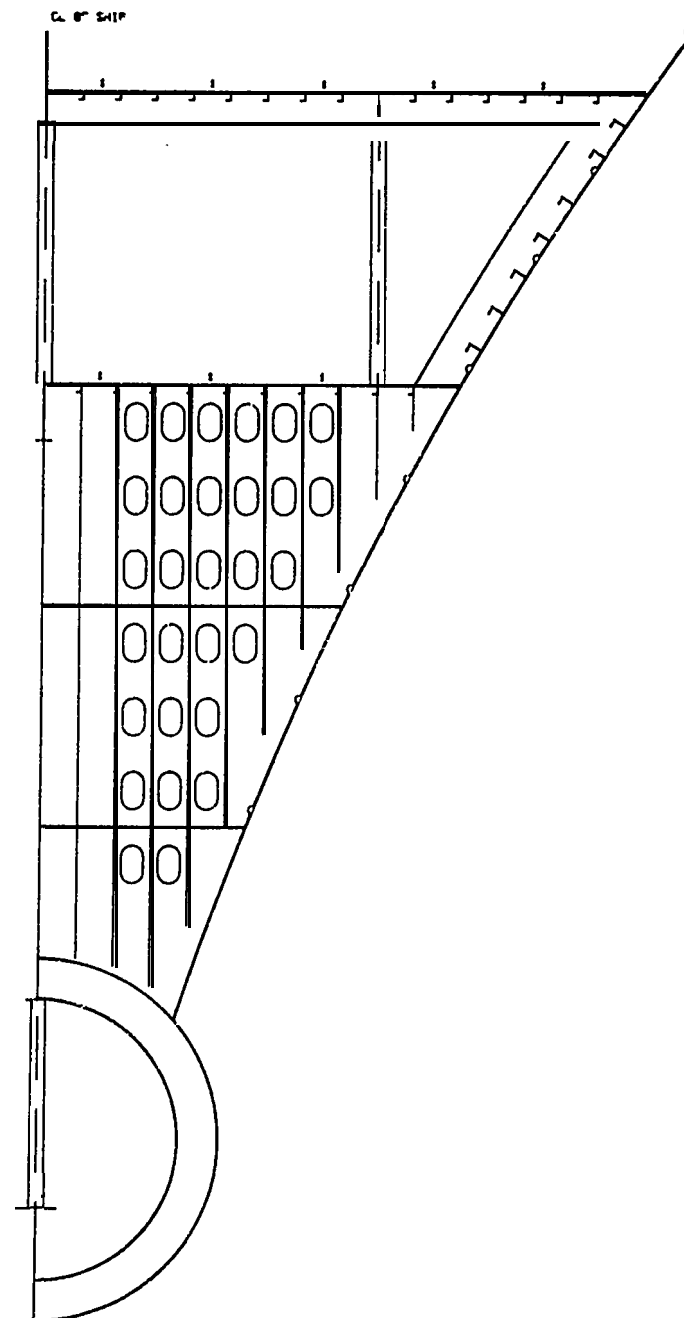


FIG. 13

<u>Line/s</u>	<u>Remarks</u>
8	DRA 654: Calls the DRA described in Figure 12. A1 - FR 133 A2 thru A4 are the distances from the centerline to the various decks A5 is positive so stiffeners are plotted. A6 represents the distance to last stiffener
9-10	DRA 404 & 401 plot additional stiffeners
11	Value to be recorded in a table designated "B"
12	DRA 306 plots main deck girder
13	DRA 305 plots 32 ft-9-1/2-in. platform
14-16	Plots frame web
17-22	Plots bulb frame
23-24	Adds value to "B" table for bulkhead stiffener spacing.
25-28	DRA 300 & 303 plots bulkhead stiffeners.
29-33	Adds value to "B" table for access openings
34-40	DRA 412. Access openings
41-45	DRA 350 plots stanchions
46-48	DRA 382 plots deck butts
49	Pen up, return in a straight line to start point, pen down.
50	stop
51-53	Text: Will annotate the drawing
54	ESSI: Command to punch tape
55	Scale factor to scale drawing to 3/8" = 1' -0"
56	Fin: End of manuscript

The entire drawing is then stored in the data base. Once stored the drawing can be recalled whenever needed and drawn to whatever scale is required by varying the scale on the N/C Plotter. Often only a portion of the stored drawing is required for some specific purpose. To accommodate this need a "windowing" feature was incorporated into the system whereby only N/C data for that portion of a stored drawing within specific bounds is produced.

Figure 14. Windowing: this figure illustrates three windows called from the stored drawing of LNG Web Frame 113.

The input information is simply X rein, X max, Y rein, Y max.

The three views shown are:

- (a) Above the 62 ft. Flat
- (b) 62 ft, Flat and below to the bulb
- (c) The bulb

### PLAN FORMATS

The structural plans for Quincy's most recent contracts were produced by construction unit, or block. That is, each plan contains all the data required to fabricate and assemble a specific building unit. A unit plan consists primarily of views of those portions of the major structural systems (shell, decks, webs, bulkheads, etc. ) to be assembled as part of that unit. The use of the N/C drafting method described is particularly suited to this approach to plan preparation since each plan is made up of a series of partial views or windows of major structural systems.

Our approach is to use the N/C plotter to draw a series of windows of structural systems, as appropriate to a specific unit, on the original tracing medium. This "Plan Format" containing the basic views describing the structural configuration of the unit is given to the designer/draftsm to complete. In this way he does not spend his valuable time doing the tedious drafting of repetitive structural geometry and the laying out of frame lines and other hull contours. Instead he can concentrate on his special talents as a designer. The reduction in manual effort also allows more views to be included on a plan, thus increasing its clarity and the amount of information provided.

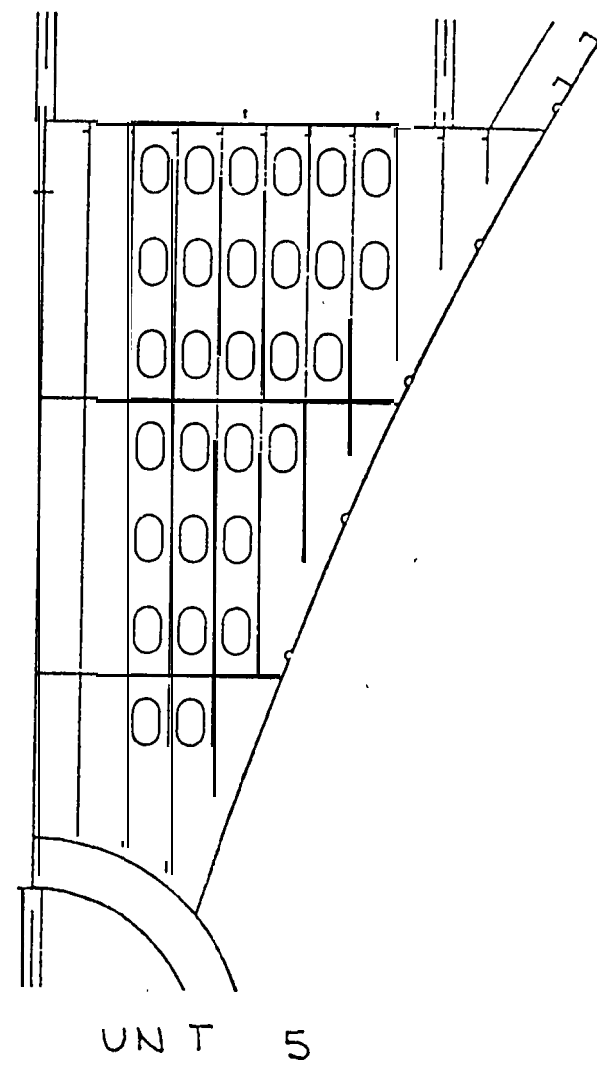
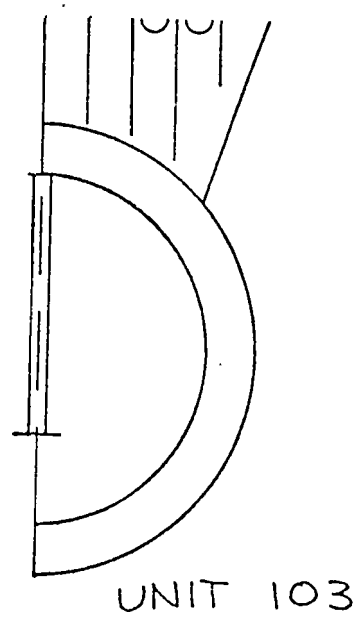
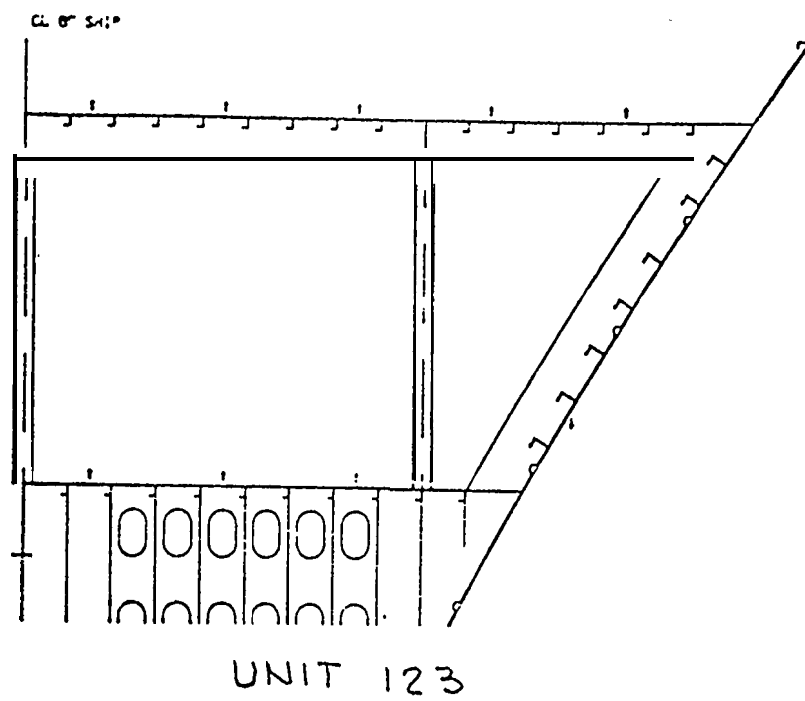


FIG. 14

Figure 14 shows three windows selected from one stored drawing. Each window is part of the Plan Format for a different structural unit plan. The AUTOKON system also allows for selecting a window from the stored shell expansion drawing. All windows can be drawn at any scale desired. We have used this method successfully in producing plans for the Liquefied Natural Gas tankers now under construction at Quincy.

Figure 15. Plan Format Specification: Plan Formats are created to specific instructions contained in a “Plan Format Specification” prepared for each plan. The positioning and scaling of each view is indicated requiring the overall arrangement of the plan to be thought out in advance by the designer/draftsman and approved by his supervisor. An area for estimating the savings in manual effort by preparation of the format is included to provide a means for identifying the savings realized.

Figure 16. Plan Format and Finished Plan: A Plan Format containing the series of windows related to a specific plan is shown together with the same plan as completed by the designer. The degree of assistance to the designer in relieving him of tedious repetitive detail is demonstrated.

While the method was developed primarily to assist in the production of structural unit plans, the concept also was applied to other types of plans. The method was particularly helpful in preparing structural backgrounds used for the machinery and distributive system composite drawings. Using the same structural system data developed for structural unit plans, entire web frames or machinery space flats were drawn on mylar at the enlarged scale required and the balance of the drawing added manually. This data was also used to provide formats showing the background structure for arrangement drawings. The extended capability of the Parts Program provided by the DRA routines also enabled us to provide specific graphical information upon request. Considerable time was saved by providing windows of structure drawn at the large scale required for preparing developmental sketches for

# AUTOKON PLAN FORMAT SPECIFICATION

PLAN TITLE: UNIT 730 - 731

PLAN NO.: 401-383-09

PLAN SCALE: 3/8" CODED SCALE: \_\_\_\_\_

ADM SETTING: \_\_\_\_\_

VERIFIED: \_\_\_\_\_

DATE REQ'D.: \_\_\_\_\_

CHARGE NO.: 40212

TIME FOR MANUAL EQUIVALENT: \_\_\_\_\_

60

NOTES: SHEET # 1 of 2

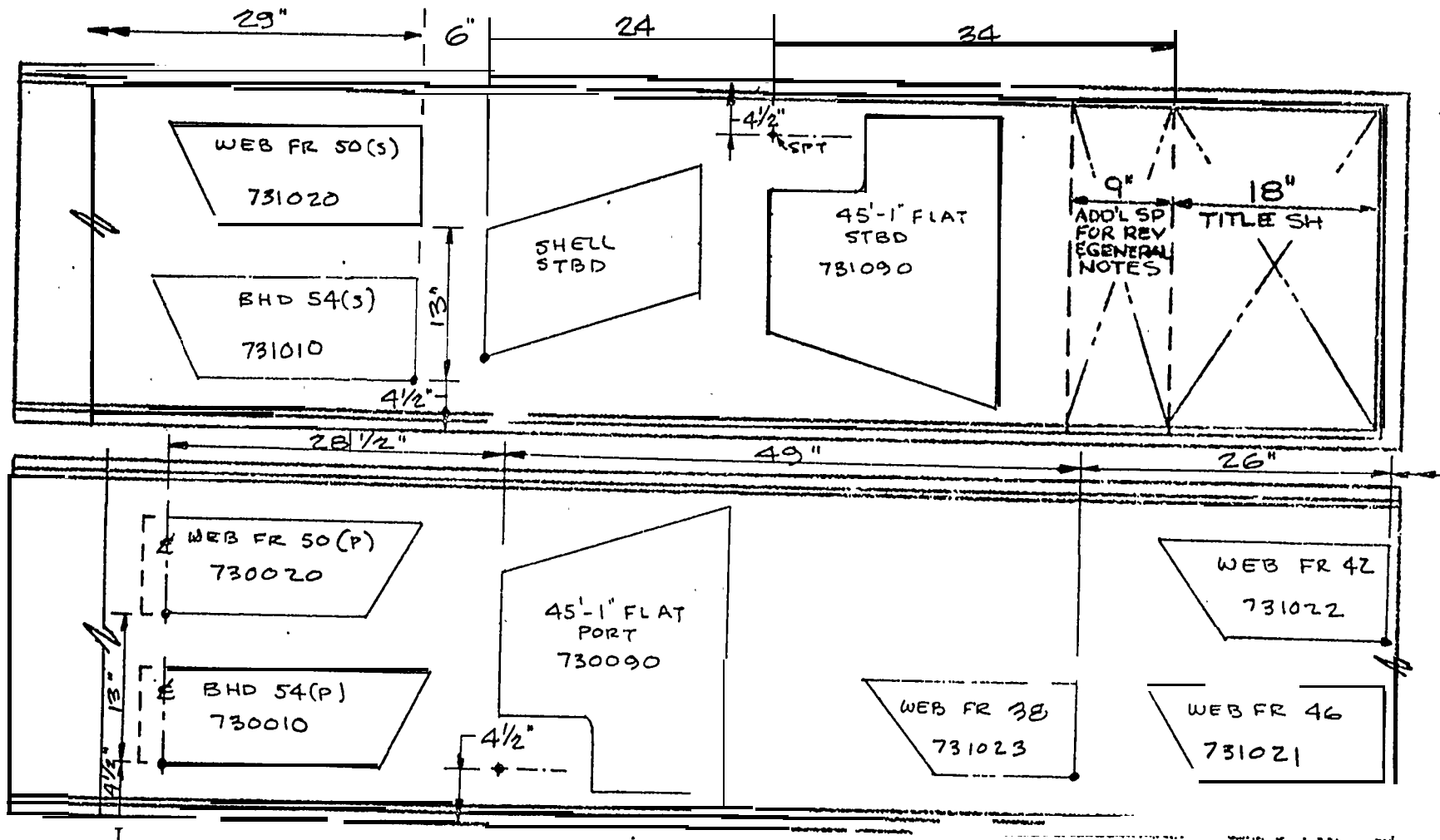
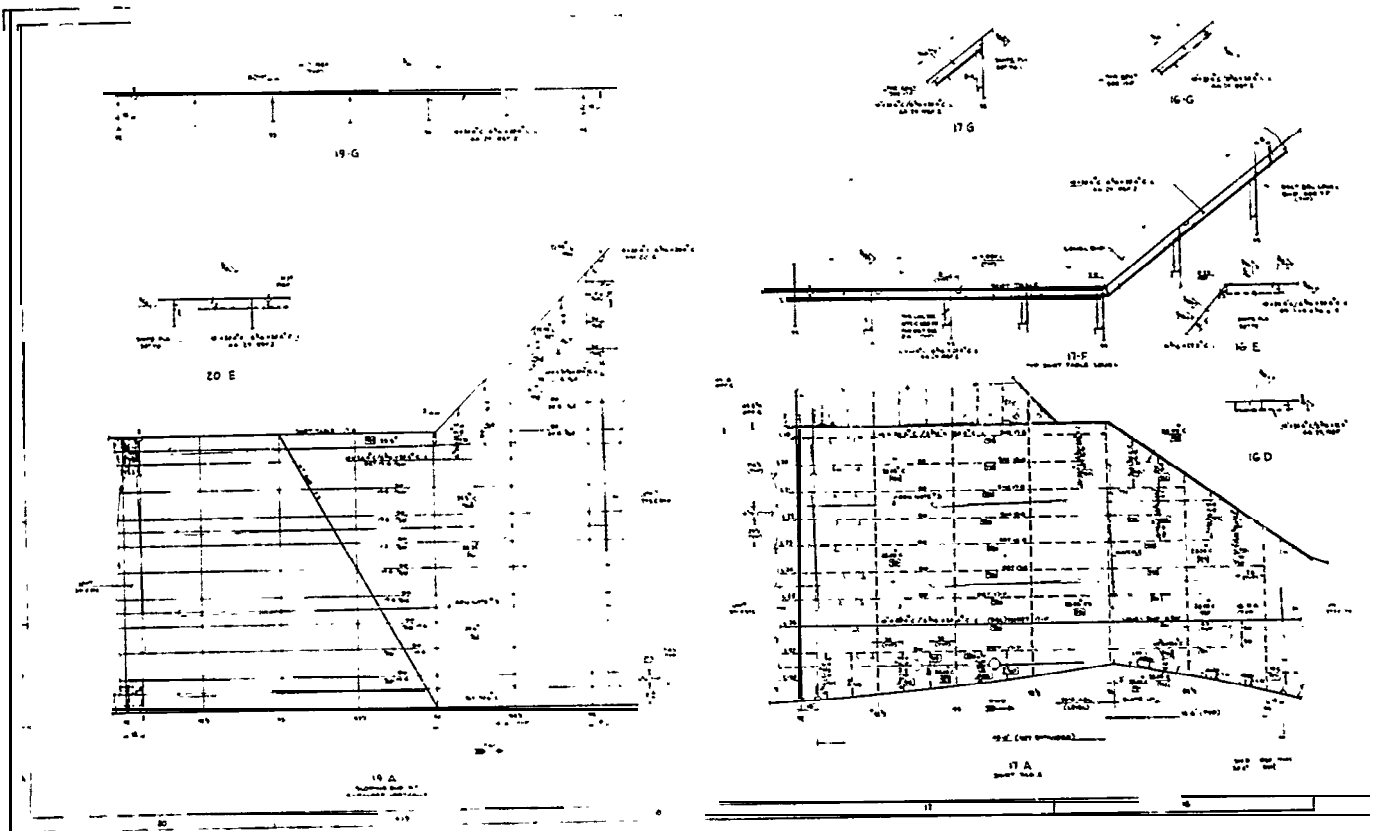
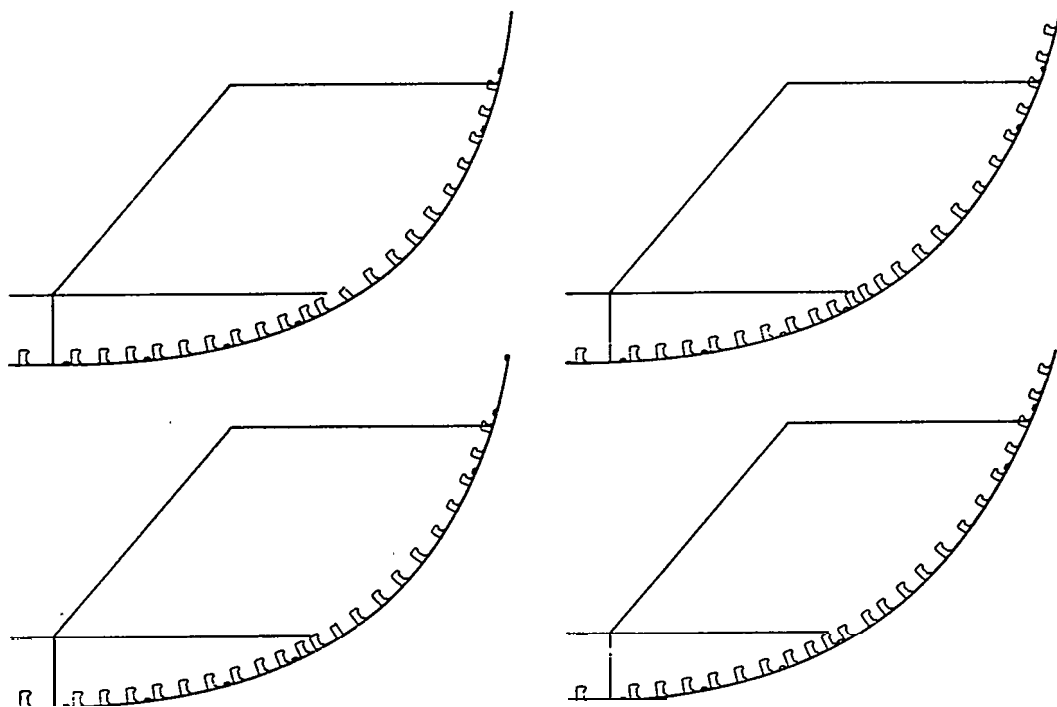
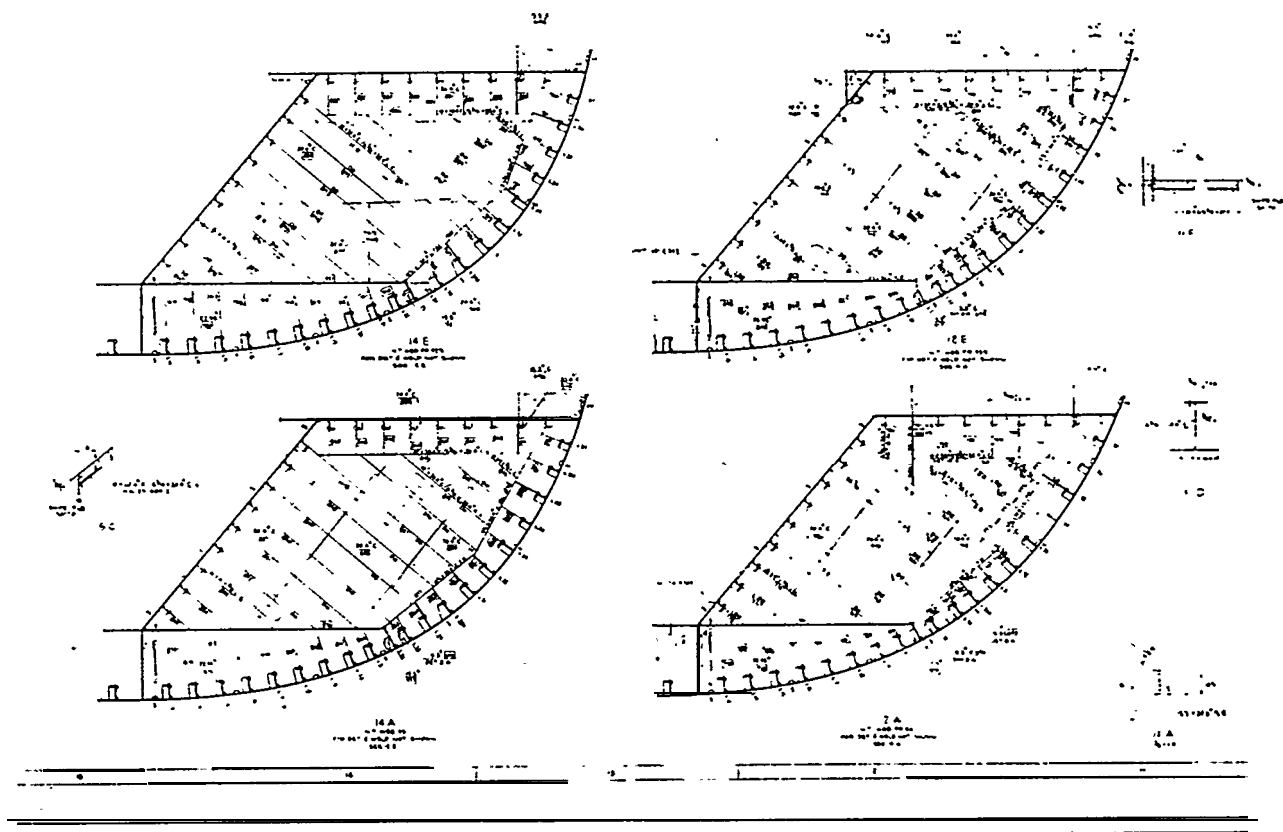


FIG.15







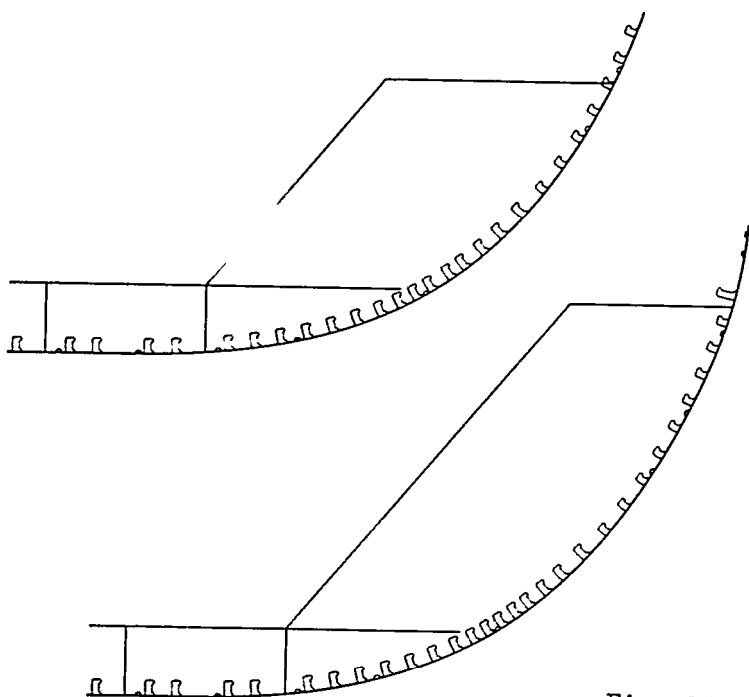
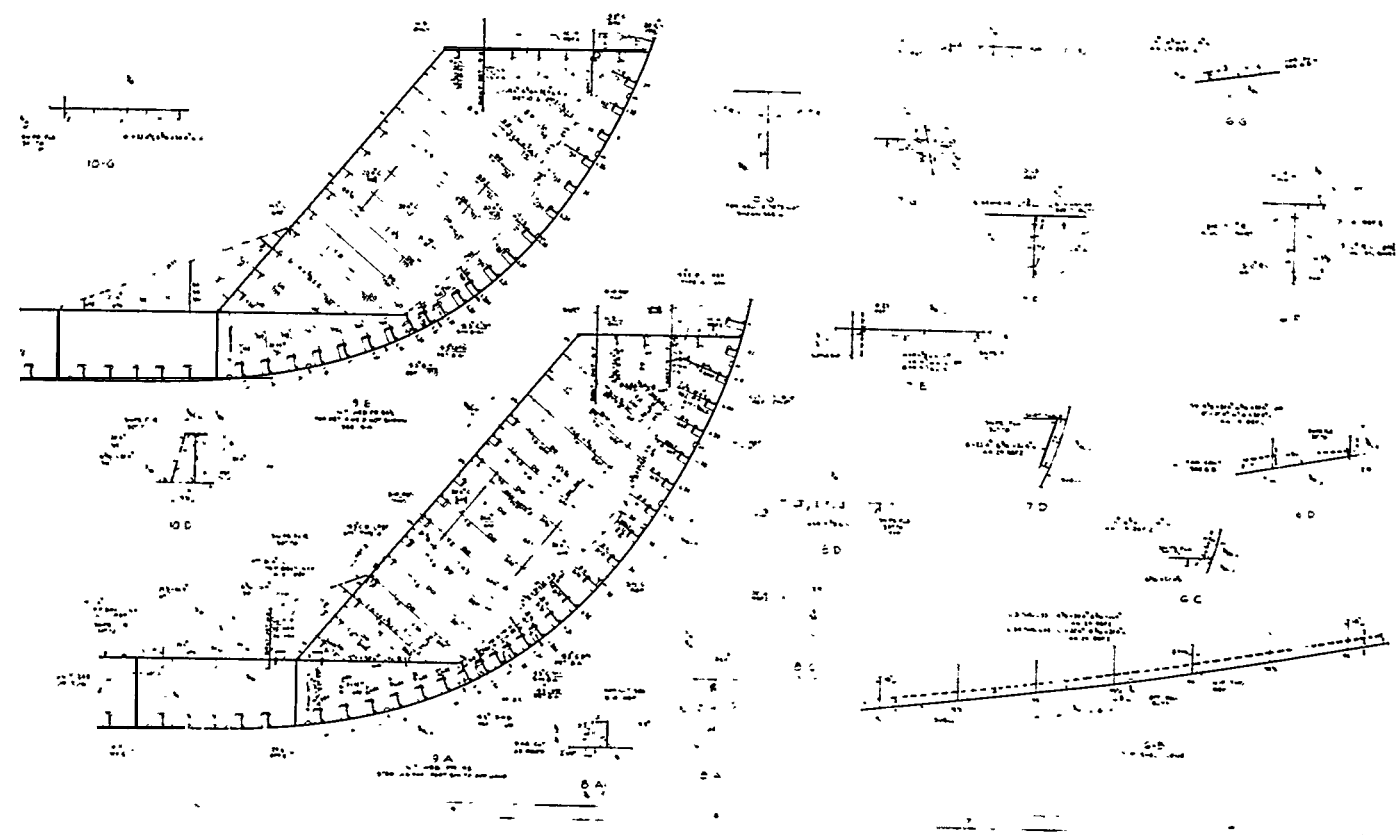
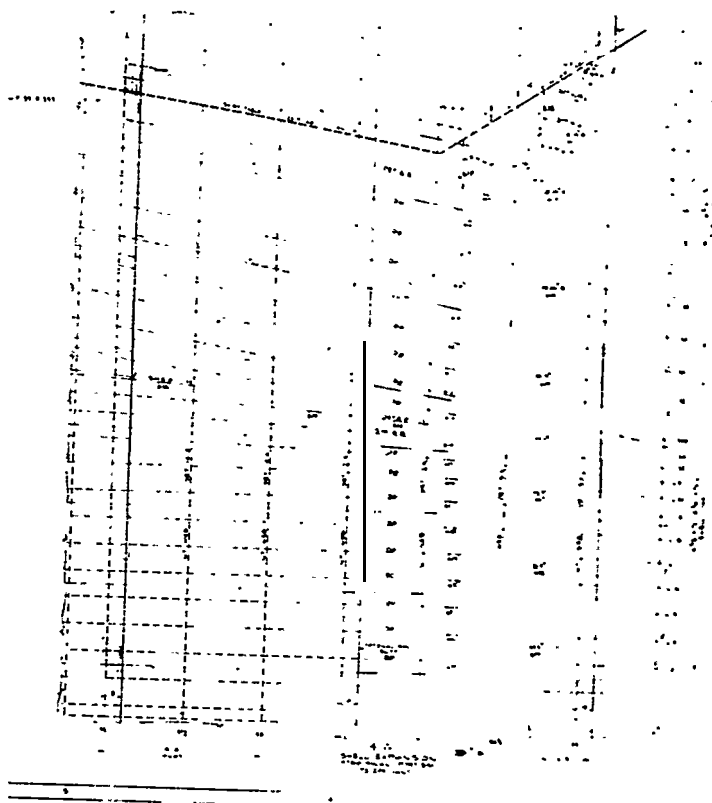


Fig. 16 (Cont'd)



GENERAL NOTES

1. SEE PLAN FOR DIMENSIONS AND NOTES.
2. ALL DIMENSIONS ARE IN FEET AND INCHES.
3. ALL WALLS ARE 12" THICK UNLESS NOTED OTHERWISE.
4. ALL FLOORS ARE 4" THICK CONCRETE UNLESS NOTED OTHERWISE.
5. ALL ROOFS ARE 6" THICK CONCRETE UNLESS NOTED OTHERWISE.
6. ALL CEILING ARE 8" THICK CONCRETE UNLESS NOTED OTHERWISE.
7. ALL DOORS ARE 36" WIDE UNLESS NOTED OTHERWISE.
8. ALL WINDOWS ARE 48" WIDE UNLESS NOTED OTHERWISE.
9. ALL STAIRS ARE 36" WIDE UNLESS NOTED OTHERWISE.
10. ALL ELEVATIONS ARE IN FEET AND INCHES.
11. ALL NOTES ARE IN FEET AND INCHES.
12. ALL NOTES ARE IN FEET AND INCHES.
13. ALL NOTES ARE IN FEET AND INCHES.
14. ALL NOTES ARE IN FEET AND INCHES.
15. ALL NOTES ARE IN FEET AND INCHES.
16. ALL NOTES ARE IN FEET AND INCHES.
17. ALL NOTES ARE IN FEET AND INCHES.
18. ALL NOTES ARE IN FEET AND INCHES.
19. ALL NOTES ARE IN FEET AND INCHES.
20. ALL NOTES ARE IN FEET AND INCHES.

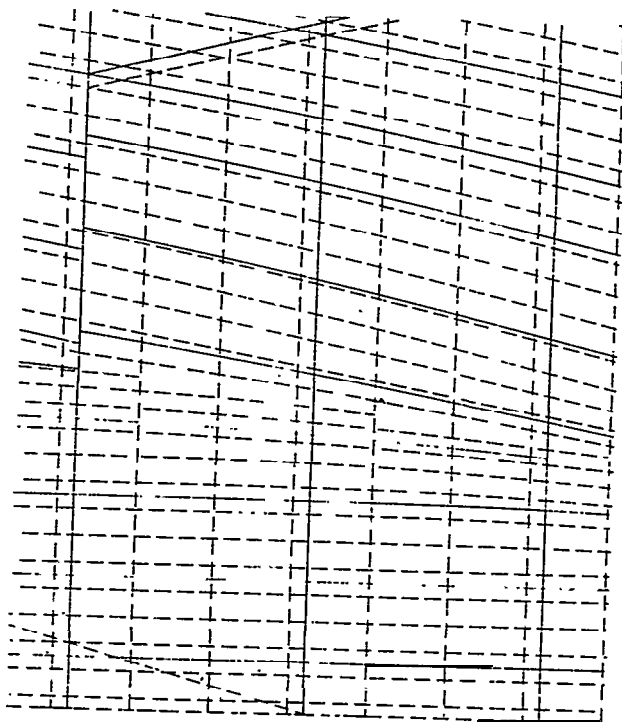


Fig. 16 (Cont'd)

such complex designing tasks as the main engine foundations and stern tube support structure. Savings were also realized using the DRA routines for non-structural applications such as the drawing of large tables for the plumbing fittings schedule. In this case, the task of drawing the many parallel lines required was performed by the N/C plotter.

Some Plan Formats, such as those for the Lines Plan, Shell Expansion Drawing and Non-Destructive Testing Diagram did not require DRA's but provided substantial savings through extensive use of stored data.

Figure 17. Inboard Profile: Two of the most popular N/C drawings were the inboard and outboard profile. This view was used at varying scales as the format for several working plans as well as in conjunction with the preparation of the unit erection schedule and several promotional pieces.

## IMPLEMENTATION AND RESULTS

A hull designer with no computer experience was trained in the use of the AUTOKON language and assigned full time to develop and code the drafting macros (DRA's) and major structural systems as shown on contract level plans. The cognizant designers/draftsmen prepared the plan format specification, coded the input data for the necessary windows and operated the N/C plotter which drew the format or other graphical data. This personal involvement created interest and enthusiasm which led to good acceptance of the method. The value to the designer/draftsperson is relief from the tedious researching and drawing of lengthy and repetitive structural geometry as well as increased confidence in the reliability and accuracy of the data provided.

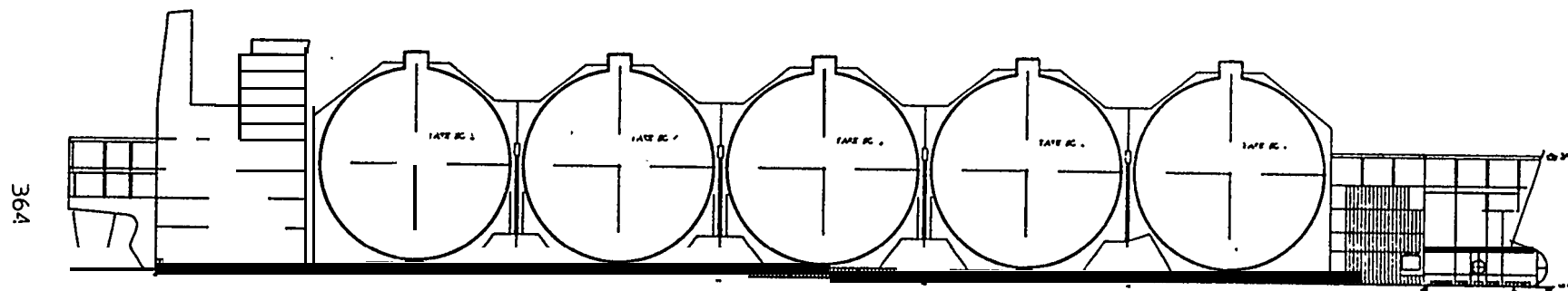


FIG 17

A total of 77 plan formats, or 11 percent of the 693 plans required for the design, were prepared in support of the LNG drafting effort. The method was conceived and macros developed concurrently with the LNG plan production effort, thus precluding its use on those plans with early start dates. The percentage of plans formatted is expected to increase significantly on future contracts since the method is now implemented and the DRA's and related N/C system macros completed. The method can now be applied to plans with early start dates such as those structural unit plans required to support early steel fabrication. In the structural area, 36 percent of the plans were drawn from formats, while 13 percent of the piping and mechanical plans used this semi-automated method. In addition to the plan formats, 44 development sketches were prepared for structural application and 30 for piping and mechanical tasks. Our experience on this design indicates that future use of the method will include a significant number of engineering drawings and electrical plans.

A total of about 272 hours of N/C plotter time or about 2-1/2 hours per plan were required to produce the formats and sketches. The plans for this design were drawn using ink on tracing cloth. This combination limits the speed of the plotter to about 30 percent of maximum. Ink on mylar allows full speed operation and would reduce plotter usage. Another 200 or so hours of plotter time were used in developing DRA's, structural systems and proving "windows". However, use of the plotter extended over an 18 month period, and no significant conflict with the validation of the N/C data for production parts occurred.

The labor savings for the LNG design, the first contract for which the method was implemented, were greater than anticipated. The experience gained through its use should yield even greater returns on future design efforts.

The savings in labor realized for each individual application of the method was estimated by the designer and his supervisor and noted on the related

Plan Format Specification. The total of these estimates indicate an average 10 percent saving in manhours to produce each plan.

The development costs of creating the basic drafting macros and any changes or additions to the N/C system related to the method are on the order of 500 hours, and the cost to code the 86 structural systems to support the LNG plans was an additional 1000 hours. The labor hours to produce the “windows” and the drawing of plan formats on the N/C plotter were about 1/3 of the hours saved and were included in the cost to produce the related plan. The computer costs will vary for each installation but can be estimated using experience with Parts Definition programs as a basis.

The method depends on several factors which may limit its success at some shipyards. Accurate structural system data must be available early enough in the design cycle to allow adequate time for coding and storing prior to scheduled plan starts. Cost effectiveness of the method will be reduced when working plans are not drawn by construction unit, since the windowing approach reduces the coding effort required. Also, any requirement to keep the stored data current will quickly erode any savings, since it is far more economical to handle changes on the original tracing as with manual drafting.

## CONCLUSION

Application of the AUTOKON I Parts Definition Language to the production of LNG working plans established the feasibility of computer aided drafting using N/C languages.

The extent of savings possible by this method depends primarily on the type of plans produced. Those plans allowing maximum repetitive use of stored data will yield greatest returns.



While AUTOKON I was used in the case illustrated, the same techniques can be readily applied to other N/C system languages and utilized by any shipyard with an N/C parts coding capability. The coding skill required to produce the necessary macros is well within the level required to support a normal parts coding effort.

A REPORT ON THE 1976  
AUTOKON USER'S CLUB MEETING

Haakon Saetersdal  
Shipping Research Services, Inc.  
Alexandria, Virginia

Mr. Saetersdal is a consultant with SRS responsible for systems support for the AUTOKON system in North America. In the past, he helped develop AUTOKON/PRELIKON and was group leader for AUTOKON maintenance in Norway.

The AUTOKON User Club was established in 1971 at Kongsberg, Norway. The purpose of the Club was to give all the users of the AUTOKON system a forum where they could discuss common problems, exchange information and present papers on AUTOKON-related subjects. Annual meetings have been held in different places in Europe since then. This year's meeting was arranged on May 11 and 12 in Bandol, a very nice little French town 80 miles from Marseille, hosted by the yard Chantiers Navals De La Ciotat which presented a perfect arrangement. About 50 participants from 13 yards and SRS were present.

The first topic was "A User's Technical and Economical Considerations of AUTOKON." Papers were presented by the hosting yard and the Italian yard Italcantieri. The papers and the following discussions revealed that it is easier to give technical rather than economical considerations. The papers contained a lot of information on the technical operation of the system in the yard, but very little data about the economics. The question arose whether the yards consider this kind of information confidential or if they really do not know too much about it. One of the yards indicated, however, a 16% reduction of people since AUTOKON was installed. For a tanker of 3,60,000 tdw., they used about 9,000 man-hours and 130 cpu hours on their IBM 370/145 computer. No indication was given as to if and how much the use of AUTOKON and N/C was saving in the fabrication of steel.

The Aker Group of Norway presented a "User's Guide to the Norm Packages" developed by the Group. The packages contained between 600 and 700 norms. It was, therefore, considered essential to break this down into smaller, more comprehensible units. By using these norms, it is possible to build a full description of the scantlings of a steel structure and to utilize this

information to produce drawings, material lists , weights, centers of gravity, etc. , for assemblies. All the norm packages have been made as general as possible by making a hierarchy where the lower levels of norms are increasingly general. The higher level norms may be modified due to structural requirements, but will still use the same lower level norms. The user's guide describes how to use the norms in sequence to obtain a result within the specified framework.

A paper dealing with the practical use of a norm package was presented by the French yard Chantiers De L'Atlantique. They have used ALKON from layout to production on the double bottom of a container ship. The double bottom is usually a well-delimited part of the ship structure, and a good picture can be obtained from above, that is, looking at a horizontal projection of the tank top. These facts make it a relatively easy start point for design by norms. The actual norm package used was developed in cooperation with the Aker Group and Chantier De L'Atlantique.

As indicated at last year's meeting, the emphasis for further development of AUTOKON would be put on the norms and programs using a more direct communication between software and the users. This policy was reflected this year by the already mentioned papers on norms and by the following session of "Interactive Graphics."

SRS presented thoughts about "Computer Graphics Hardware and Application in Shipbuilding," giving data about available hardware configurations, prices, etc., and future use of interactive techniques. So far SRS has two applications using graphic displays in operation. The first is the interactive nesting program which is working on a mini-computer and a Tektronix 4014 display.\*

\*Also presented at the 1976 REAPS Technical Symposium. See pp. 133 in this Proceedings.

Another new system is under development and is planned to be an information system for outfitting and pipe production. The system AUTOFIT will be realized in steps; the first step is now operational.

The French company CSEE demonstrated two applications working on a mini-computer and a refresh type of display called Afigraf. The applications were a nesting program and a program for calculating longitudinal strength of a ship in different loading conditions. Even if no new programs are taken into use, a graphical display unit may be utilized, e.g., to make fast verification of output from other programs (AUTOKON-PRELIKON). This is done to a certain extent by the Aker Group and IHC, Holland, which demonstrated this together with some other applications.

Some advice was given about AUTOKON database management, which may be of interest to users in the U.S. as well.

Some users copy the database to a backup file, every time an AUTOKON program is executed. Since the rewriting of AUTOBASE, this is not necessary due to the high security of the system.

The optimum fill percentage of the record catalogues is about 60% to 80%. This means that the database should be initiated with few catalogues and increased as the database grows.

The afternoon of the last day was devoted to a visit to the hosting yard in La Ciotat. The yard is capable of building ships up to 380,000 tons dead weight. In the last two years the throughput has been over 100,000 tons of

steel with 5,900 employees. AUTOKON has been used since 1970 and, at present, they have the intermediate solution on an IBM 370/145 computer.

After the tour of the yard, the conference for 1976 was concluded. The next year's meeting will be held in Trieste, Italy.

The following appendices incorporate those papers presented at the meeting which appear to be of most interest to U.S. shipbuilders:

- A. "Report From Chantiers Navals De La Ciotat," Mr. Gaillard, CNC, France.
- B. "Hull System at Italcantieri Company," Mr. De Luca, ITC, Italy.
- C. "User's Guide to the Norm Packages," Mr. Mack, Aker Group, Norway.
- D. "ALKON From Layout to Production on the Example of a Double Bottom," Mr. J.P. Boisard, Chantier De L'Atlantique, France.
- E. "Computer Graphics Hardware and Application in shipbuilding," Mr. O. Eng., SRS A/S, Norway.
- F. "Interactive Graphics at ICS," Mr. Maisson, IHC, Holland. 26

REPORT FROM CHANTIERS NAVALS DE LA CIOTAT

Mr. Gaillard, CNC, France

1. INTRODUCTION

The aim of the this report is to present the C.N.C. adaptation of the AUTOKON System. Voluntarily have chosen a practical approach for the first 3 chapters in order to clarify the encountered user-problem and to describe necessary developments during the implementation and use of AUTOKON.

Such a system must sooner or later be evaluated on the basis of available resources mobilized by the system and on the engendered expenses. The chapter 4 of the report yields in a rather precise way the number of man hours and the number of computer hours for a big tanker constructed at C.N.C.

It is almost certain that this approach, if adopted by the other shipyards present at this meeting, may lead to very fruitful discussions.

## 2. THE AUTOKON SYSTEM AT C.N.C.

### 2.1. Available programs

C.N.C. has used AUTOKON in 2 versions :

- from November 1970 to November 1971 : AUTOKON 1
- from November 1971 and up to present date : AUTOKON 71/Inter-  
mediary version.

The later version contains the following programs:

- FAIR 2 + DRAW 2
- LANSKI + SHELL 2 + TEMPLATE
- TABELL + NYRISS
- PART
- 3 - NEST 2 + PRODA.

### 2.2. Implementation phase

The offices concerned by the implementation and the use of AUTOKON belong to 2 different departments at C.N.C. :

#### a) Design department.

The drawing office for the lines plan and hydrostatic calculations (B.E.C.) carries out a fairing procedure of the body plans based upon manually developed hull forms. The AUTOKON program FAIR 2 is used for this purpose. Two draftsmen take care of the fairing.

The Hull drawing office (B.E.C.N.) completes the body plans by generating longitudinal curves using the LNGIN module of LANSKI. By aid Of SHELL 2, the same office makes a preliminary shell plate development of curved plates for the purpose of material specification. One draftsman is partly occupied by these tasks.

The Scientific Section ensures the maintenance and the developments of the programs and gives technical assistance when the users encounter particular problems. Besides, this section carries out the daily AUTOKON computer runs.

#### b) Production department

- The Numerical Drawing Service is the C.N.C. office most concerned by AUTOKON activities and it handles the following principal jobs:

Definition of the table of longitudinal elements

Shell plate development and templates

Part generation

Nesting.



## 2.3. Available resources

### a) Computers

- One IBM 370\145 768 K with
- 4 mag. tape stations, type 3420, having 1600 bpi, 9 tracks and 120 K 0\sec.
  - 2 disks, type 3330, having 800 million octets in line
  - operating system : os/vsl.
  - One IBM 1130\8 K which can if necessary be coupled to the the IBM 370\145 as on-line terminal.

### b) Drawing machines

C.N.C. has at their disposal 2 KONGSBERG drawing machines : a type 1830 in the Production department and a type 2637 in the Design department; the latter being used for body plans and completed body plans in scale 1 : 10. Each of the tables is controlled by a HONEYWELL H 316 computer.

### c) NC equipment

4 Logatomes (AIR LIQUIDE) can be optically or numerically controlled by :

directors\_CC 200 - 2 axis mode  
---2-KONGSEERG directors CC 300 - 3 axis mode

### 3. DISCUSSION ON THE AVAILABLE SOFTWARE

#### 3.1. General remarks

This discussion deals mainly with the modifications carried out by C.N.C. in order :

- to correct detected errors
- to adapt the software to our particular demands
- to improve the program performances.

Our basic intention is to have confidence in the SRS developed programs and only to carry out modifications if intense use shows that it is necessary. In other words, modifications depend entirely on the results of programs. This policy, however, implies a good knowledge of the programs, but it had become necessary in the beginning when taking into account the following 3 constraints :

- the absence of an SRS maintenance group as well developed as now
- the difficulties of information exchange due to the distance especially the delay of urgent decisions needed for some problems.

We are aware of the possibility that this policy may not be agreed upon by other yards or SRS.

The improvements have been developed taking into account that system versions such as ALKON exist having a better performance than our present version. By this means we have tried to avoid useless expenses in manhour and money.

#### 3.2. Error induced modifications

When considering the size of the AUTOKON system, it becomes evident that these programs cannot be completely free of errors of different origins. The number of detected errors generated during the programming phase of AUTOKON We not been overwhelmingly large. As they are only of minor interest, we will shortly give a survey of encountered principal problems :

FAIR 2 suffers from following 4 points :

- Insufficient precision of the intersection calculations especially around the endings  
Initial impossibility of using more than 350,extra points (input\output errors in the file of extra points)
- For the transverse frames, wrong selection of ending points on the side
- Impossible to use the direction curves called BDRD.

DRAW 2 (last SRS version) :

-Impossible to draw the space curves in their 2 plane projections of fairing.

LANSKI :

Our comments are related to the modules PCURV and PRNUT. When considering PCURV, it was impossible to draw a network if the starting point was identical to the final point (see figure N0.1)

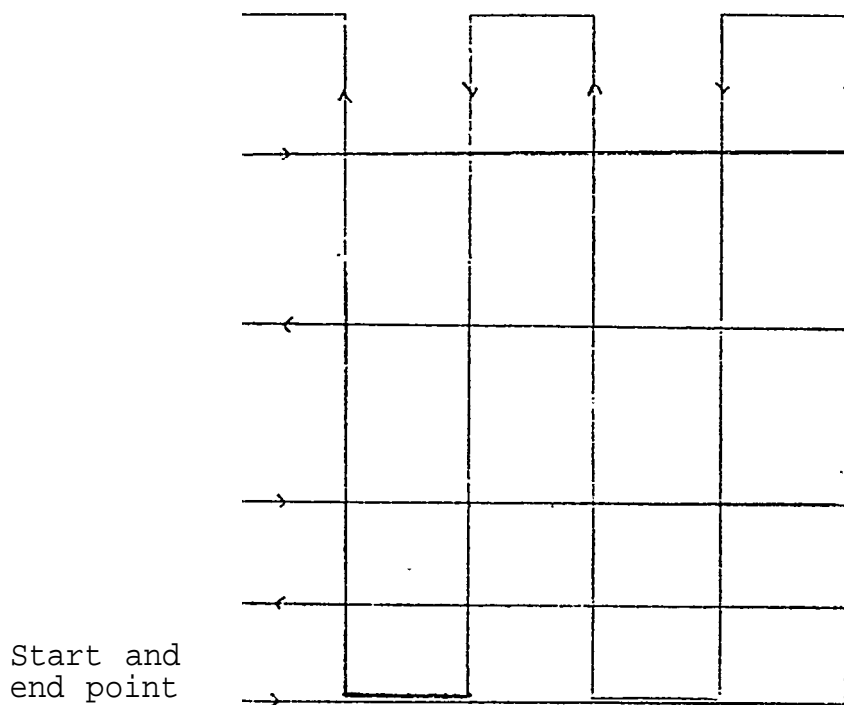


FIGURE No 1  
LANSKI

The longitudinal curves are reduced to a point in certain projections, e.g. longitudinal curve on the parallel middle body plating parallel, to the x-axis will be shown in the yz-plane as a point.

TO avoid punching of drawing tape, the program PCURV tested whether the first and the last point are the same (tolerance  $\epsilon$ ) or not. This test has been replaced by a test of the length of the projected curve.

Concerning PRNUT, the angles E and F vary every time LANSKI calls this module.

## NEST 2 :

The use of this module at C.N.C. raised the following three points of criticism:

- Poor elimination of small elements, i.e. elements where the  $|\Delta u|$  and  $|\Delta v|$  are both inferior to a given fixed tolerance. The Auxiliary Function Word (AFW) of the deleted element was assigned to the next element.

In the chord fitting subroutine, the AFV of the circular elements was assigned to all generated chords leading to errors if the positions should be edge marked.

Due to a wrong calculation of the auxiliary functions for edge marking (we remember that these functions are based on the normal direction of the element in question for edge marking) the determination of the direction was false. This problem was repeated in PART.

SHELL 2 in its old version has a wrong development of the plates crossed by tangency lines in the bottom or at the side. This problem has not yet been solved at C.N.C. in spite of the information furnished by SRS because of the structure of our SHELL 2 version.

## 3.3 Modifications for obtaining better methods<sub>1</sub>

The improvements consist of either new possibilities introduced in existent programs or completely new programs based on the experience gained during the use of AUTOKON.

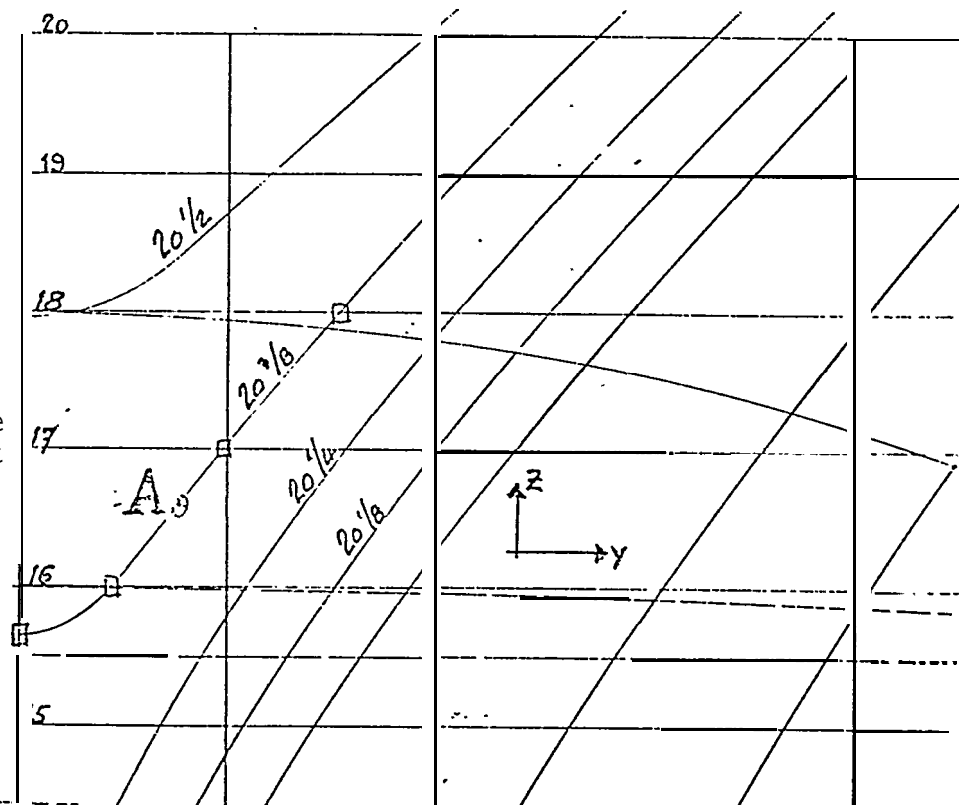
### 3.3.1. New possibilities within the AUTOKON system

#### F A I R 2 :

In its original form, the space curves gave as results the points for all the TFR, WL, BTCK intersecting the space curves concerned. This could be inconvenient, e.g. if the points which are necessary for the determination of the water line endings are obtained from the space curves, then it is sometimes not useful to include the so-obtained point when carrying out fairing of the frames in the extreme fore part or after body of the ship (cf. point A in figure No 2) .

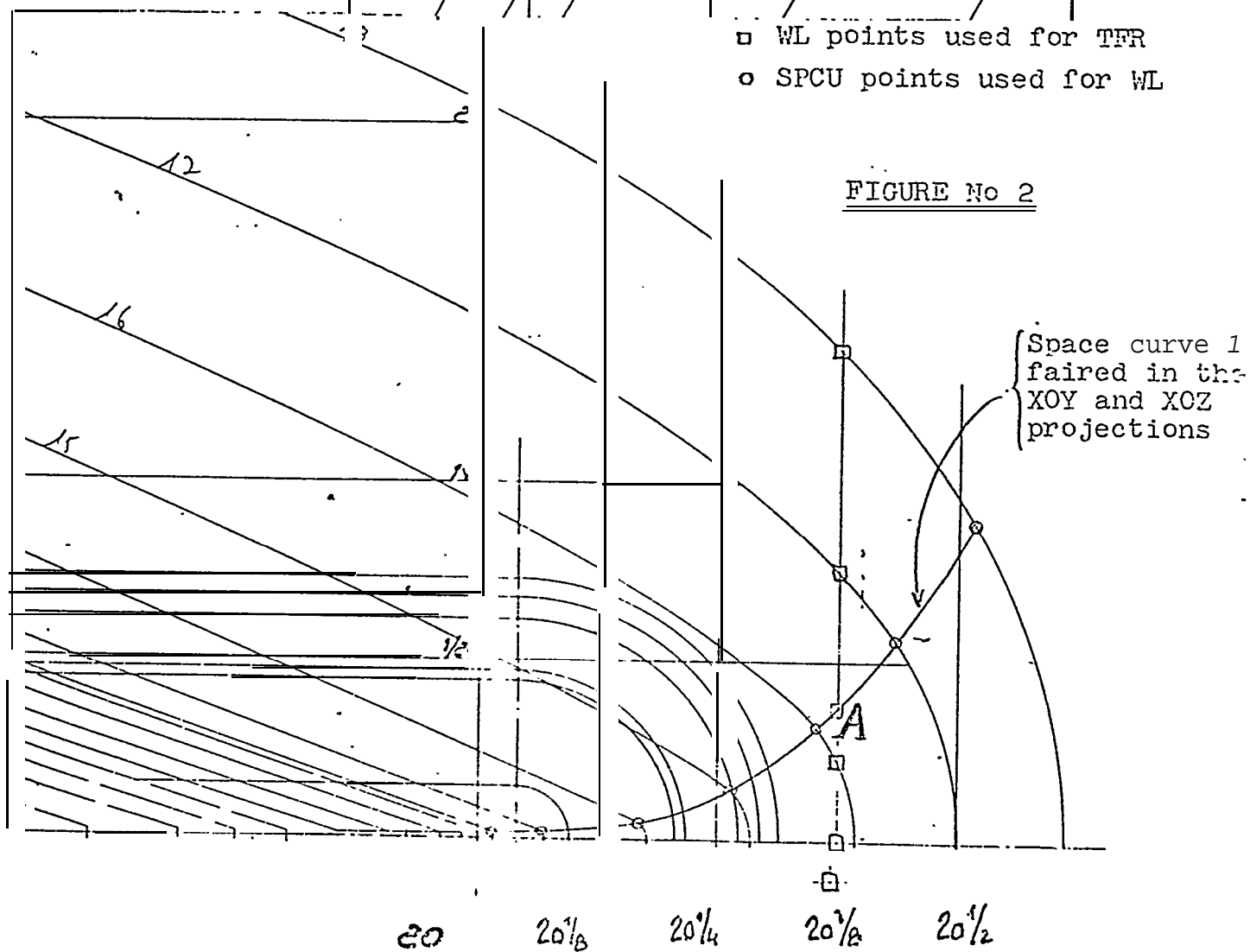
This difficulty has been solved by introducing in the definition of the space curves the possibility of choosing the projections, where one wants to conserve the intersection points. This is done by an intermediary indicator.

Point A is the inter -  
section point between  
space curve 1 and fralle  
20 3/8. Apparently not  
necessary for fairing  
of this frame.



- WL points used for TFR
- SPCU points used for WL

FIGURE No 2



LANSKI :

A new possibility of defining longitudinal curves in the  $yz$  - projection (transverse plane) has replaced the standard LANSKI possibility SLYZ (see figure No 3) .

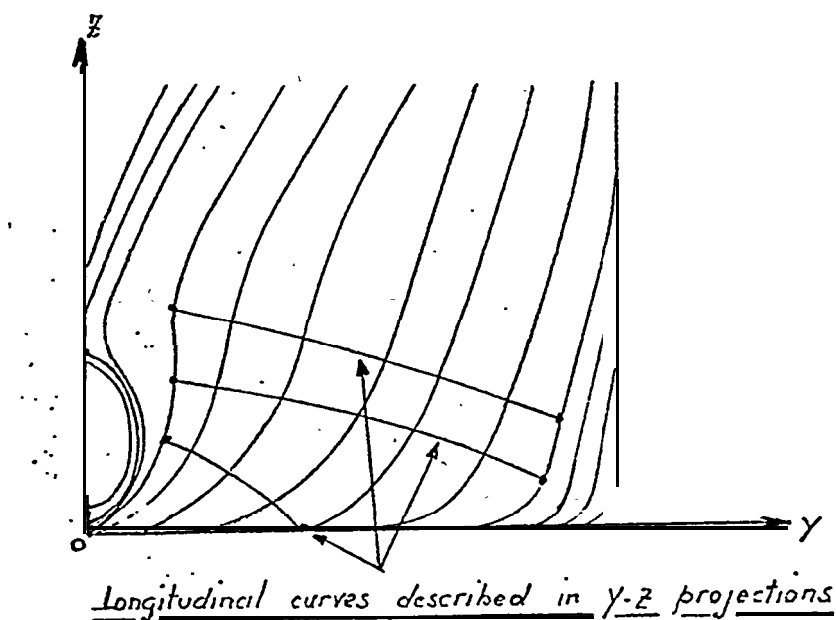


FIGURE No 3

In defining internal closed transverse sections (originally created for self-supported tanks and double hull) we obtain 2 intersection-points when cutting the transverse plane by a longitudinal vertical plane (see figure No 4 points A and B) .

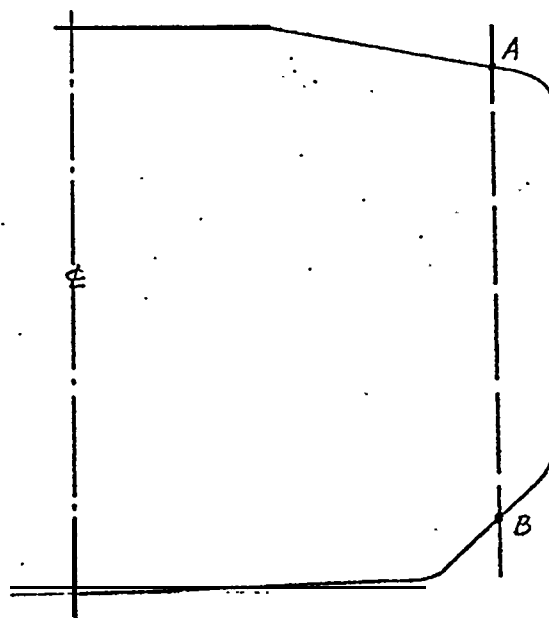


FIGURE No 4

Implicitly we have to choose one of these points either in the bottom or on the top in order to define the corresponding longitudinal curve. For each frame this choice is done as a function of a height approximation indicated in the heading of longitudinal curve in question (data sheets LNGIN).

The determination of the abscisses in the data sheet for LNGIN was given as

$$\text{frame number} \pm \Delta X.$$

This approach was not possible, if  $\Delta X$  was greater than the mesh distance value, which forced us to change the quotation system for certain plans. A modification of the program has been carried out allowing us to let  $\Delta X$  be arbitrarily chosen.

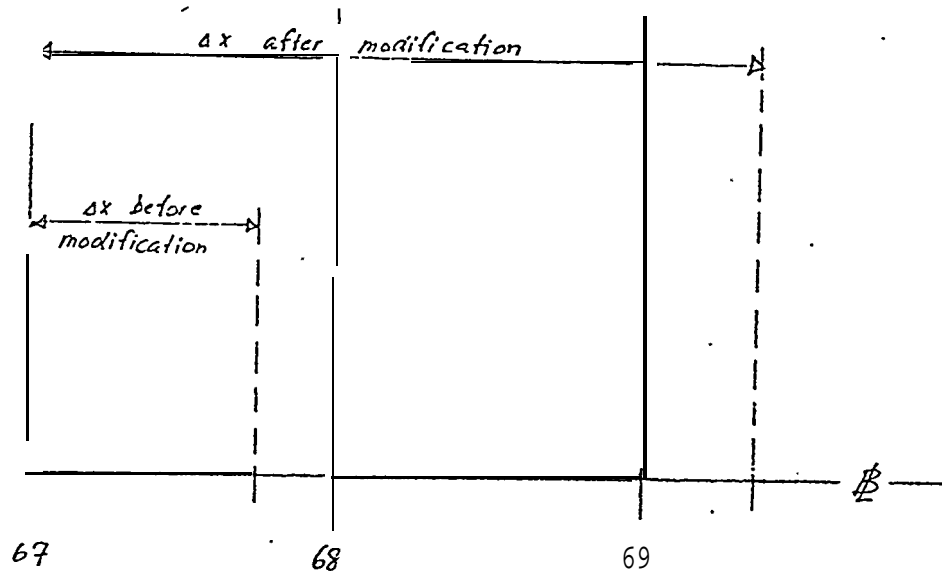


FIGURE No 5

PUNK punches, normally framewise, the table of the longitudinal elements. However, the punching for a given frame can be suppressed if it has no cut-outs.

If an asymmetrical transverse frame (asymmetric when considering the GENACONS) does not have any cut-outs where the longitudinals, causing this asymmetry, intersect the frame, then the frame in question will be declared symmetric.

#### PLTUT :

Now SRS has well. improved the visualization process in using drawing machines. But, before SRS, it was necessary to carry out ourselves a number of modifications, which as seen below are concentrated on the module PLTUT :

For the sake of clearness of the plans, the frame spacing in the projections XB, XZ, XY is drawn as marks of 200 m in length (full scale). Generally, the C.N.C. plans are scaled 1 : 100, thus giving marks of 2mm in length.

Choice between 3 kinds of dotted lines by aid of the drawing table functions connected with the H 316 computer of the drawing table.

For all projections, the axis may have different scale ratios, e.g. 1 : 50 on the x-axis and 1 : 10 on the J-axis. This possibility is mainly used for drawing diagonals on the one-tenth drawing checking the body Plan fairing.

Longitudinal curves are classed as :

```
LONG )  
SEAM ) standard LANSKI  
DECK )  
  
CARL ) (CARLingue = girder  
SERR ) C.N.C. standards : (SERRE = stringer  
PLDF ) Plafond, Double Fond =  
[top, double bottom
```

By aid of the above-mentioned key-words, our original LANSKI program may handle either all the curves belonging to the same class by giving. one key-word or certain curves from a class by specifying the key-word plus the lower and upper number of long. curves.

Possibility of windowing the longitudinal curves by indicating the upper and lower frame of the window (see figure NOS 6a and 6b). In the XB, XY and XZ projections, one obtains curves going from X min to X max. Outside this range the longitudinal curves are not drawn. In the YZ projection (body plan) the program gives, as shown in figure No 6b, not only long curves but also the intermediary frames. This possibility is very useful for the generation of working drawings.



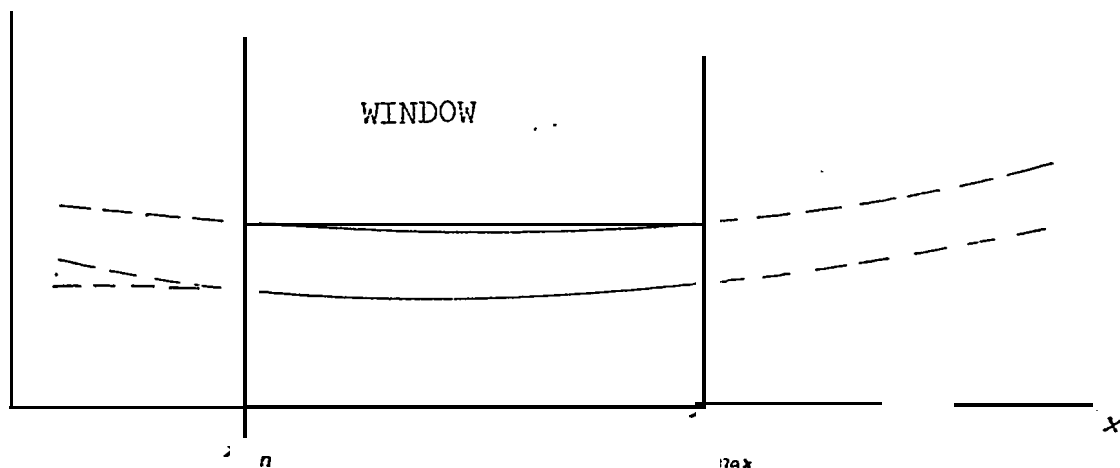


FIGURE NO 6a

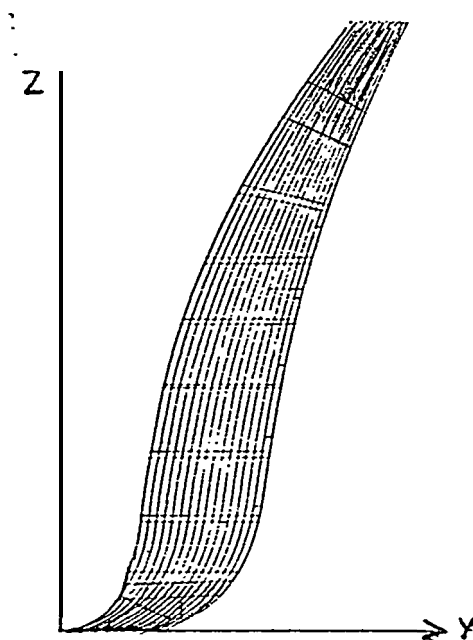


FIGURE No 6b

- Compression of SSSI elements to avoid punching of non-fundamental elements (see figure No 7). This leads to a reduction of number of punched cards and tapes .

Apparently these modifications seem unnecessary when considering the *actual level* of LANSKI, but it must be remembered that some of the  $n$  were done before the newer SRS modifications.

In this paper we have voluntarily left out of consideration the schematization of the C.N.C. formats for the computer outputs.

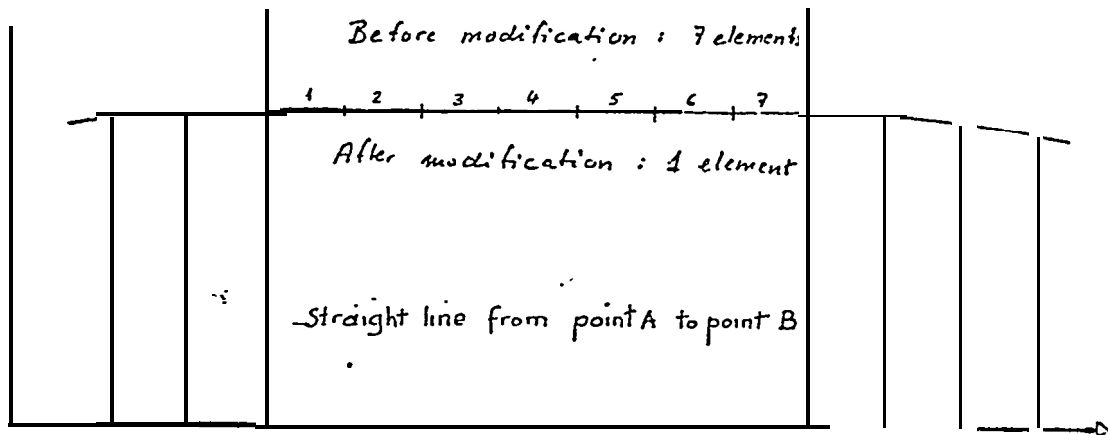


FIGURE NO 7

TABELL :

The C. N .C. version of TABELL permits directly filling in the table of longitudinal elements from the LANSKI Data Base to the AUTOKON Data Ease.

SHELL 2 :

The developed shell plates having the edges flame-cut are defined by straight line segments (which can be seen on drawings in scale 1 : 10; see figure No 8). Curve fitting is then carried out by BSCIRK.

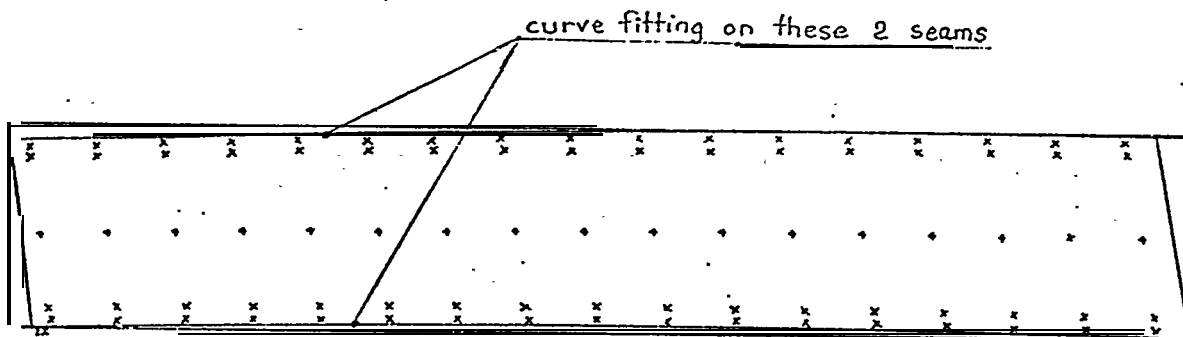


FIGURE NO 8

### NYRISS :

The C.N. C. version permits to fill in the frames from the new FAIR 2-E tape. The maximum number of elements per frame has been increased from 120 to 200 AUTOKON elements.

### PART :

USing the-time cIOCK of the computer the datum is stated in the headings of each listing to ease the data card classification and card corrections. The computer also tests the newbuilding number in order to avoid errors in the card manipulation and to ensure that structural items of one ship are not allocated another ship data base . (The newbuilding number is indicated on the JCL card) .

### 3.3.2. Developments and new programs

- a) OS/VS : Version IBM OS/VS 370/145 with 3330 disks ~~exists~~ now for all programs.
- b) FORTRAN : Change in computer language from FORTRAN G to extended FORTRAN H with optimizer, which has decreased CPU time, e.g. on the new Part Coding program; (without structure overlay) a gain of 20% CPU is observed.
- c) SCKERF : is a program for kerf width compensation. The problem is c connected with the AUTOKON description of the parts using the theoretical dimensions. After flame-cutting the resultant dimensions of the parts in question are diminished along the contour by  $l/2$  width of the kerf.

The aim of our modification was to correct the parts results before flame-cutting so that the dimensions after the frame-cutting process correspond better to the theoretical ones.

The method consists in carrying out partwise the necessary compensation. Each part exists then in the Data Base in 2 different forms :

- as a result of the part coding
- as a result of the SCKERF program.

Evidently this occupies more file space but it allow's us to simplify the treatment. of the part geometrical elements which should not be compensated (rapid traverse ) .

The program has 4 calculation sequences :

Reading phase : partwise taken from the Data Base.

Dilation (or inverse) sequence of each part is ensured by an intersection supervisor.

Calculation of a net! contour if certain intersections cannot be determined.

Storage on disk of the new dimensions (new part number = old part number + 200000) of the expanded part.

The nesting is of course made in using the compensated pieces.

d) SCFORINT : calculates simple geometrical contours. When looking at a transverse section of an LPG carrier (See figure No 9), we can detect several cut-outs on :

- the hull side
- the double hull
- the external contours of the tanks, and on
- the internal contours of the tanks.

The basic idea was to treat by AUTOKON, in the same way as the outer contours, all the internal contours (classified by level) and parts, i.e. for each level:

- 1) to define the transverse sections by AUTOKON elements (thus obtaining a result equivalent to Fair 2) 1
- 2) then use LANSKI to define all the longitudinal curves and the table of longitudinal elements.
- 3) finally applying in, the Part Coding (using GENACONS) the previously defined contours with cut-outs.

The contours are classified as follows going from the outer contour inwards, e.g.

level 0 : Hull ..... No TFR  
level 1 : Double hull ..... No TFR + 1000  
level 2 : Tank contour ..... No TFR + 2000.

The contour determination has its origin in a simple VOLUME description using a plane conception with either sharp plane plane-intersections (see figure 10a) or with cylindrical corners (see figure No 10b). Figure No 11 shows an example in three dimensions of the tank geometry of an LPG carrier. These volumes have been defined previously by hand and all information concerning this description is contained in some of the general geometry plans. FORINT, therefore, is more a descriptive than a conceptual algorithm, that we had built up with special care for simple handling and fast calculations.

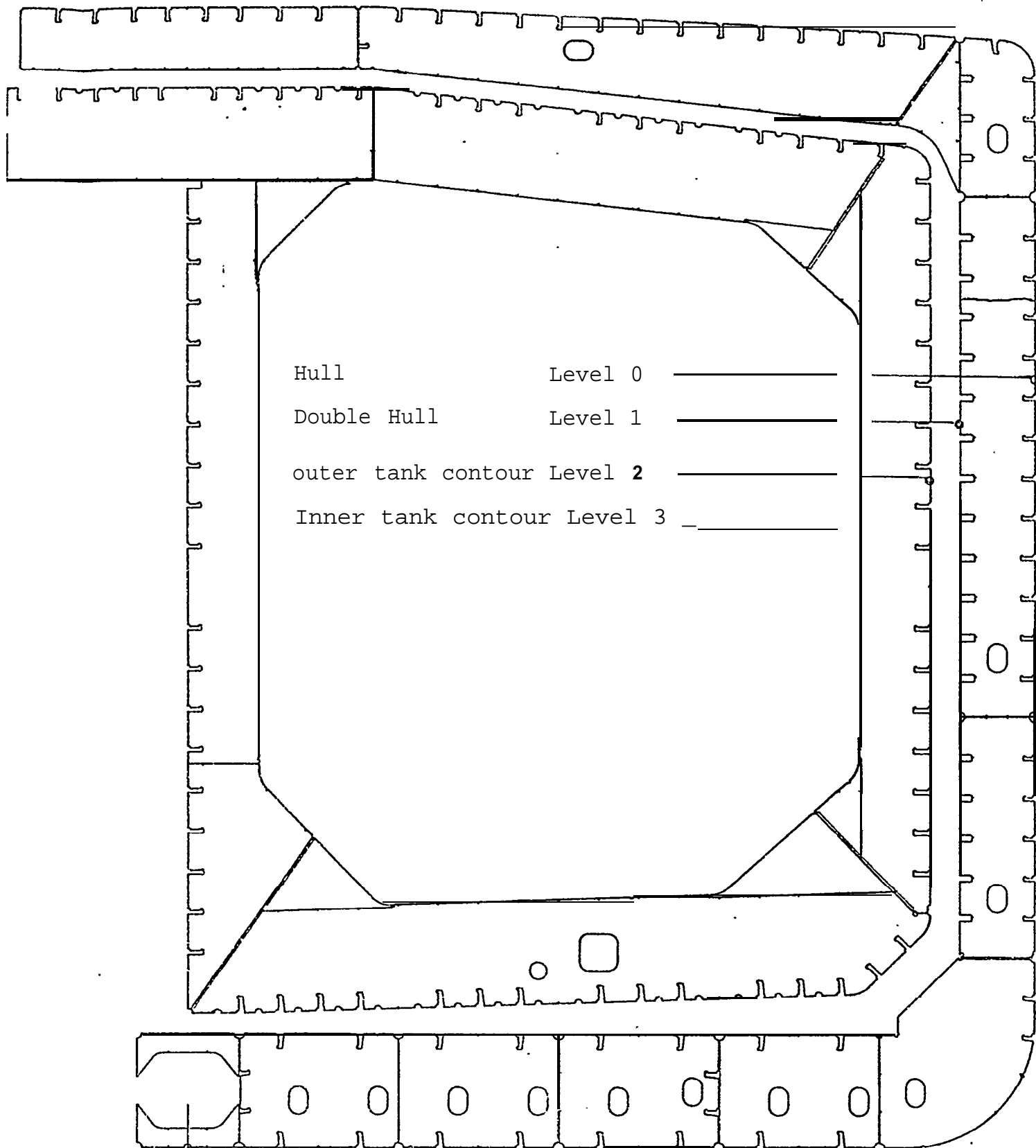


FIGURE No 9  
Transverse structural. elements of an LPG tanker

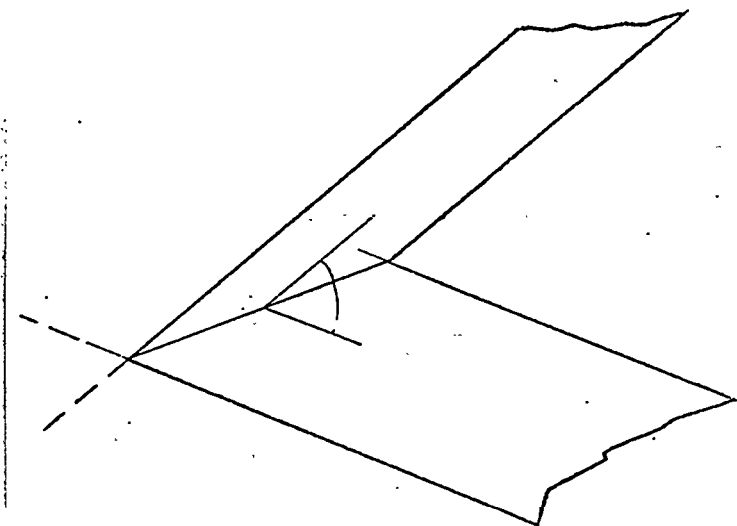


FIGURE No 10a

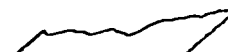


FIGURE NO 10b

The input data consists among other things of a three dimensional description of Knuckle lines linking plans together by specifying :

- the coordinates of boundary points on the knuckle line or some other elements that allow the program to calculate the corresponding coordinates.

if necessary, the radius of the cylindrical corneus (see figure No 10b) .

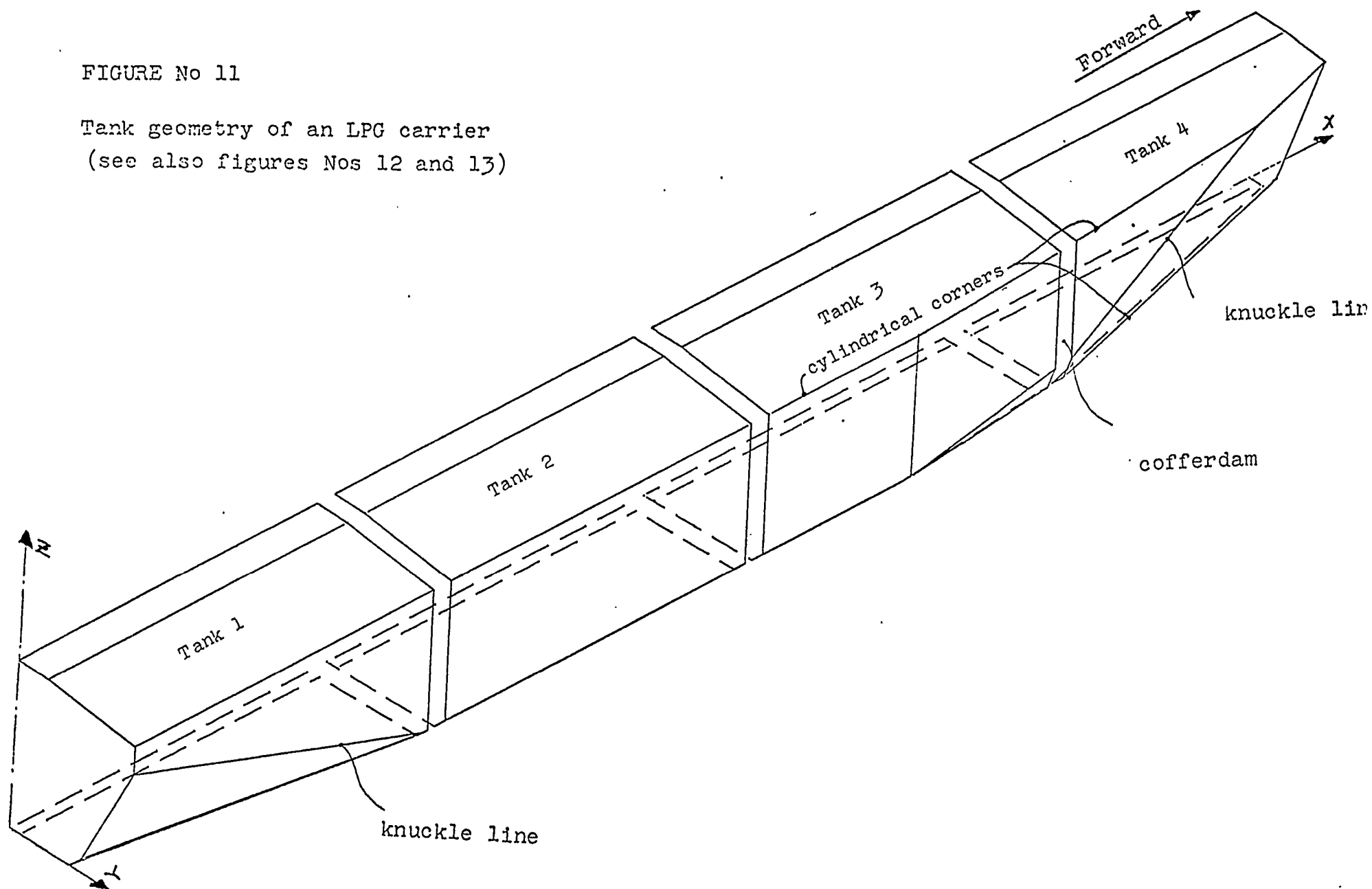
The results are presented in 2 different ways :

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>- on line printer :</li> <li>- as a file like FAIR 2 allowing :</li> </ul> | <ul style="list-style-type: none"> <li>List of input data.</li> <li>Intermediary calculation of coordinates having been implicitly defined.</li> <li>List of the curve spacings.</li> <li>Error messages.</li> <li>AUTOKON elements of the curves.</li> <li>drawing of the curves with the program DRAW 2 (see figures Nos 12 and 13),</li> <li>transferring transverse sections to the Data Base disk, to use LANSKI.</li> </ul> |
|---|---|

The longitudinal curves : The FORINT calculated contour can be closed, if the input data has been manually sorted; this has given rise to some problems

FIGURE No 11

Tank geometry of an LPG carrier  
(see also figures Nos 12 and 13)



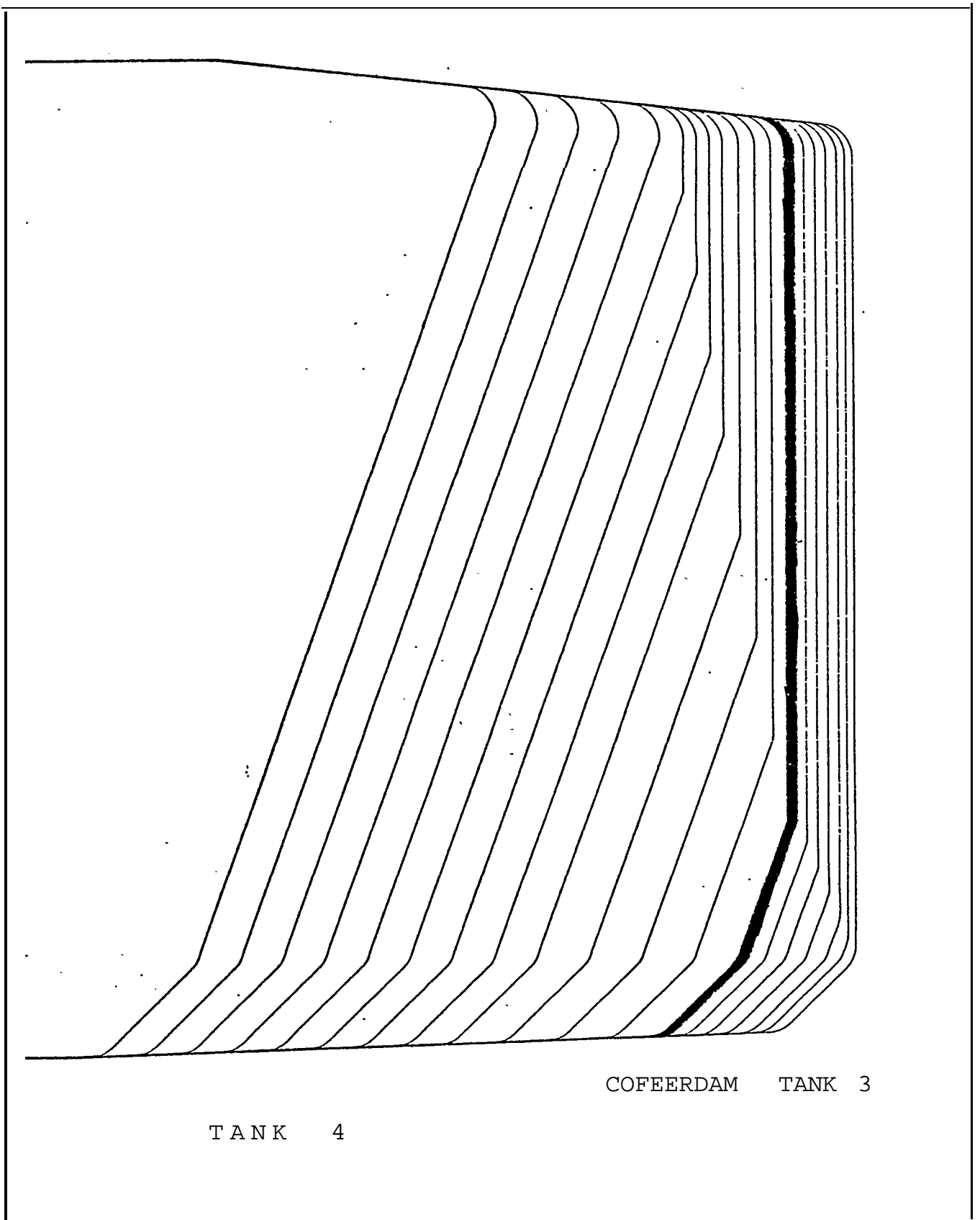


FIGURE No 12  
Forward tank geometry - LPGcarrier



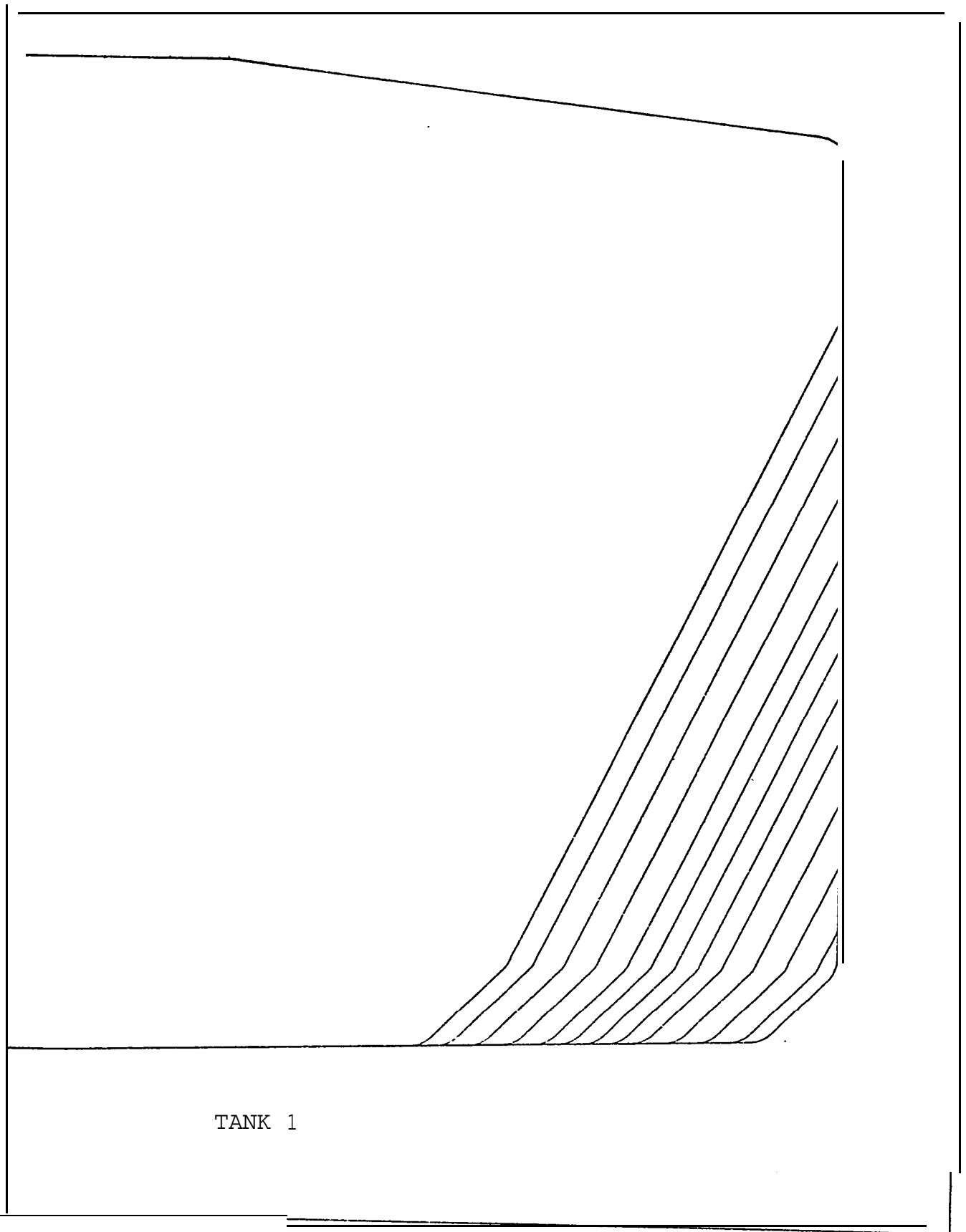


FIGURE No 13  
Aft tank geometry - LPG carrier  
393

when using LANSKI for the longitudinal curve calculation (see chapter 3.3.1) . After the modification of LANSKI, this constraint has been removed. For internal contour, however, one LANSKI run covers the whole ship (no separate aft or fore body) .

A problem connected to the Part Coding is what to call 2 GENACONS within the same part description once the table of longitudinal elements is fixed. To solve that, we were forced to create a new GENACON ( = GENACON 100) by aid of the AUTOKONJ language. This GENACON was called only when the description needed a contour generation. An example is given in the following.

#### E x a m p l e

<u>Without GENACON 100</u>	<u>With GENACON 100</u>
YN - , IDN - 1.* Generation of ACON	Y N y - , I D N -  Part Coding
	Generation of 1st ACON 1..
Part Coding with call of ACON	Part Coding 1..
ESSI FIN	Generation of 2nd ACON  ESSI FIN

The result of an example is shown on the figures 14 and 15.

#### e) TEMPLATE :

The main purpose of such a program at C.N.C. is :

- to calculate in the developed region the plane templates for every 3rd frame and if possible to choose among C.N.C. standard templates.
- to determine in the non-developed region the three dimensional templates.

Presently the C.N.C. version of ' TEMPLATE treats only plane.templates for the plates situated in the developed regions.

The computed method starts with a determination of a reference plane. For each frame, where it is desired to have a flat template, the program computes :

- all intersection points IT (see figure NO 16) between reference plane and the frame contour.

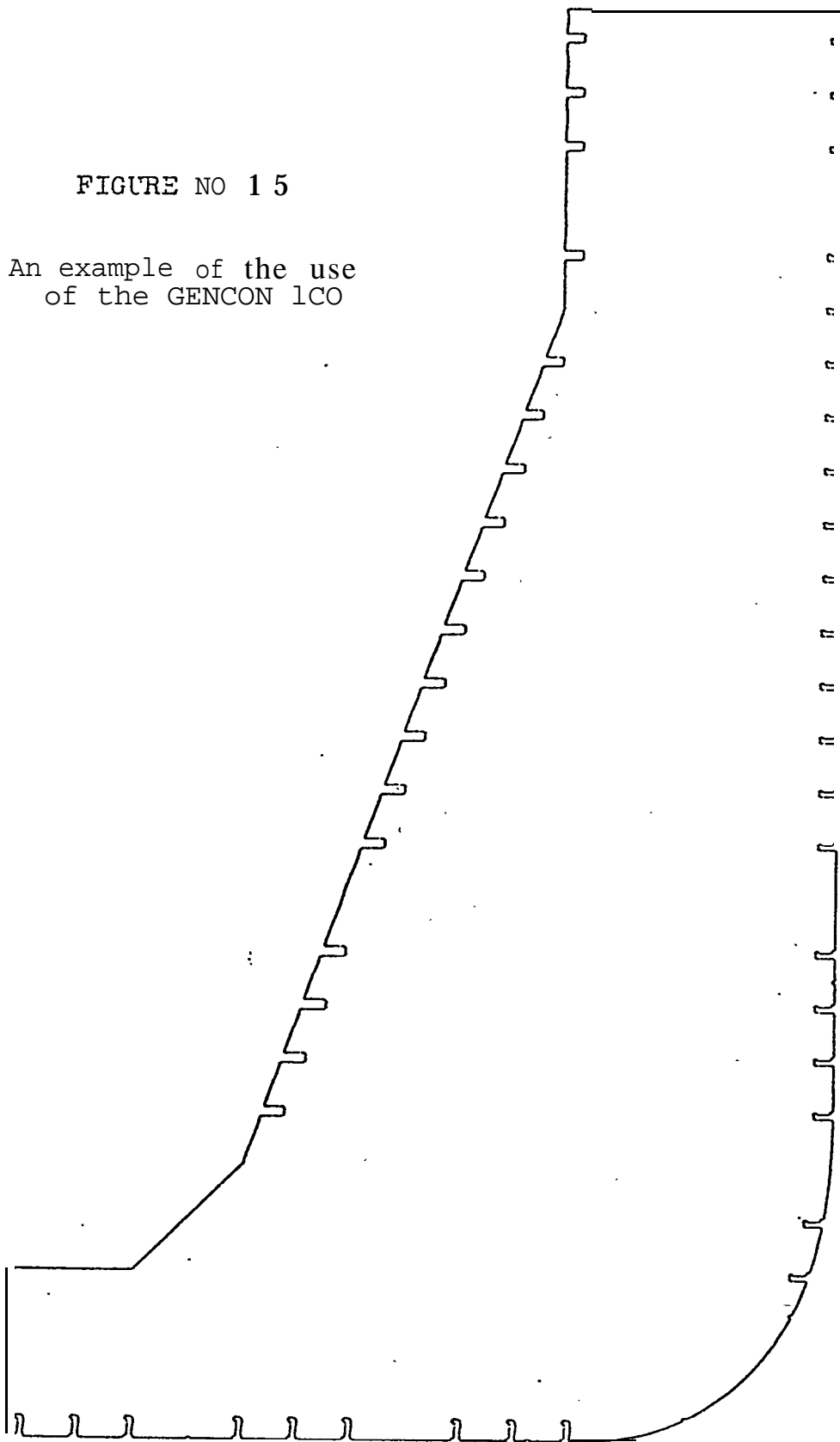
FIGURE No 14

NAVIRE 312 PIECE TRAITEE LE 27- 2-76  
\*\*\*\*\*

```
1.  COMM ( EXCMPL E O UTILISATICN
2.      DU GEN ACON 100 )
3.  SPT( +16000+22000)
4.  SL:DIR( +O)IIJT(+100+O)
5.  GEN ACON 100(-f110+1+41)
6.  INT(+Io()+O)
7.  SL:DIR(+90) PT(+5000+O) INT(+IOO*O)
8.  GEN ACON 100{+1212+22+1)
9.  INT(+100+O)
10. SL:DIR(+O) EPT(+16000+2'2000)
11. ESSI(PRESENTATION FORINT- GEN ACON 100)
12. FIN
13. &
```

FIGURE NO 1 5

An example of the use  
of the GENCON 1CO



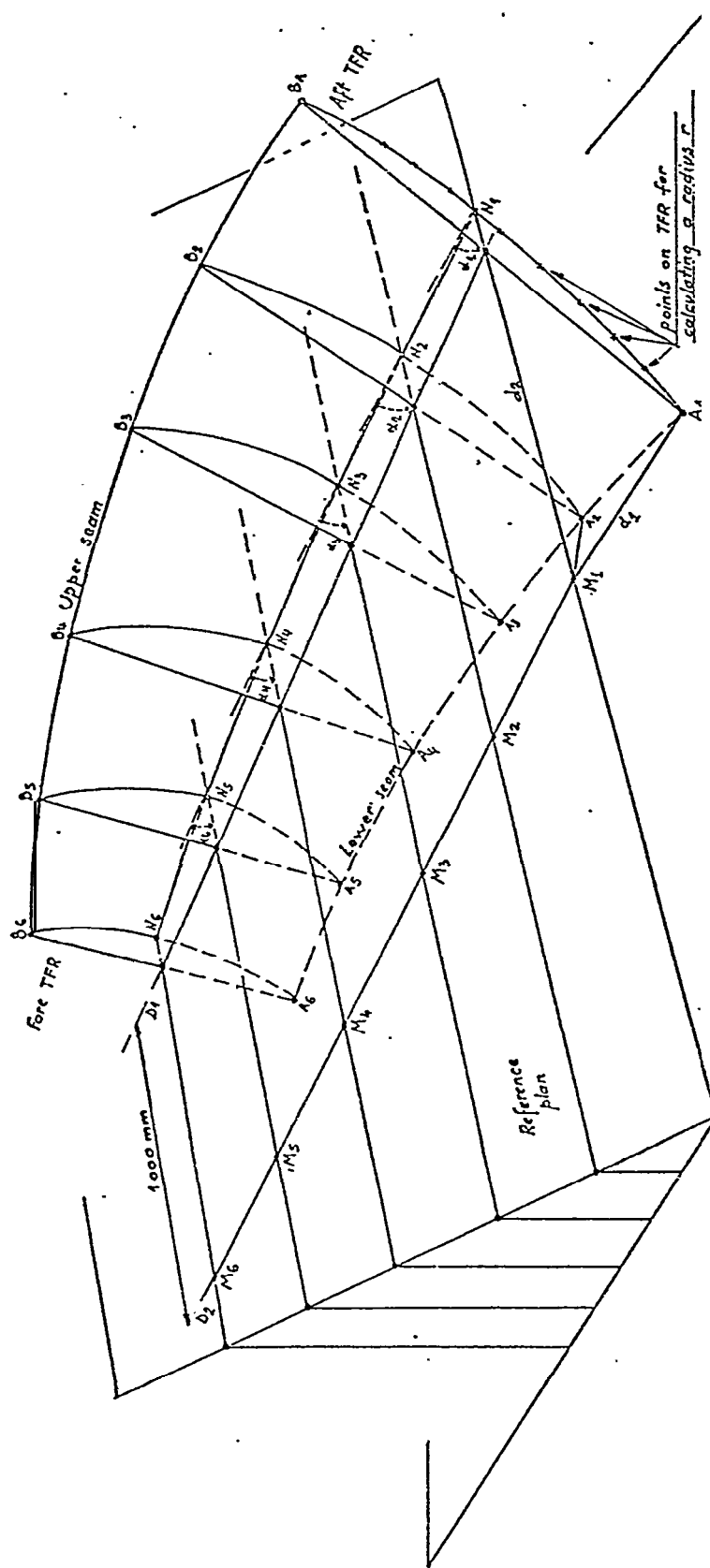


Fig. 16

all points M situated in the reference plane on the line  $D_2$  and having all a given distance (1000 mm at C.N.C) from  $D_1$ .

- the distances  $d_1$  and  $d_2$ .  $d_1 = AM$   $d_2 = MN$

10 points on the contour, if the frame does not have any double curvatures in the region concerned. Using these 10 points in a least square method, the program approximates the contour by a circle segment (see figure No 17). The found radius  $r$  may give us an indication for the choice of a standard template.

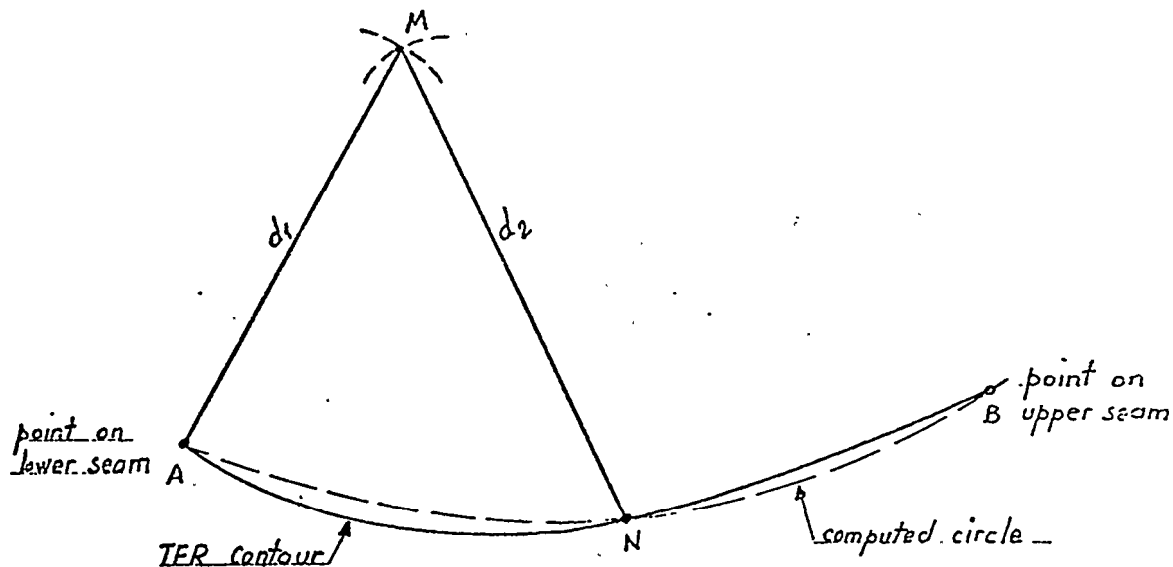


FIGURE NO 17

- finally-the bevel angles in the reference plane are calculated.

The program uses exactly the same input data as SHELL 2.

The results are presented on 2 forms .....

on line printer : The listing consists of necessary identification plus the values of  $d_1$ ,  $d_2$ ,  $r$  and  $\alpha$  for each plate and each template.

as drawings : in scale 1 : 1, which together with the line printer output permit the template construction (as shown in figure No 16).

- f) LISSE : calculates for the longitudinal stiffeners with few input data, the width along the frames and some other drawing information. See figure no 18.

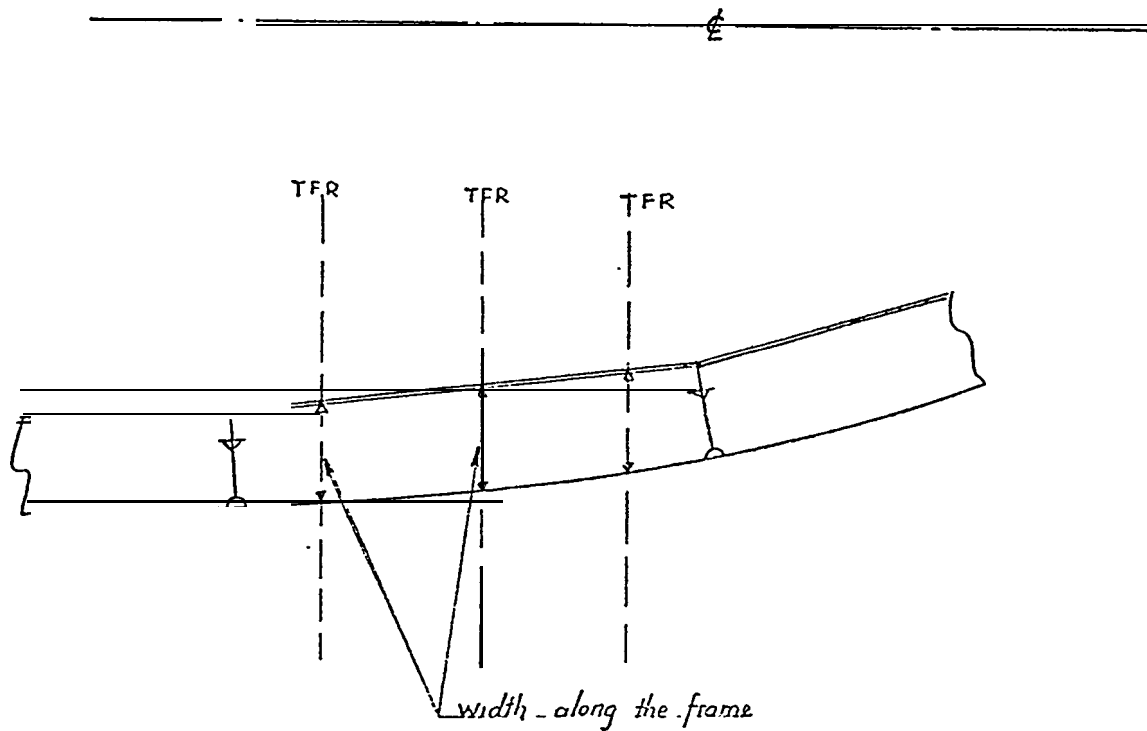


FIGURE No 18

#### 4. RESULTS OF THE USE Of AUTOKON

The results of the AUTOKON system may be defined in many ways . In this chapter we will concentrate on 2 predominant results, namely the number of employee's after the implementation of AUTOKON and the recent performance of AUTOKON at C.N.C . illustrated by means of an example .

##### 4.1 Present number of employees \*

This number is related to the 2 main C .N. C. departments :

Production department : When AUTOKON took off in 1970, the working group consisted of 7 persons; this number has gradually' been increased as a function of the amount of work undertaken by AUTOKON and has reached the actual number of 32. This group is able to handle simultaneously 3 different types" of ships .

In addition to these persons, the mould left activities necessitate 35 loftsmen; therefore, the actual total number of persons is about 67.

In the days before AUTOKON, the same jobs kept about 80 people occupied for an equal work load.

As a result of AUTOKON, we may say that 13 men have been transferred to other jobs in the production department .

Design Department : As mentioned in Chapter 2.2 the staff trained for AUTOKON tasks includes. :

- 2 draftmen for the body plan fairing (FAIR2).
- 2 draftmen to complete the body plan (LANSKI)
- 1 draftman available for norm writing if it is still necessary
- 5 programmers able to ensure the maintenance and the technical assistance.

3 Of these persons can be considered as a supplementary staff. This is mainly due to a job transfer .

##### 4.2 Recent performance of AUTOKON

We prefer to present the performance of AUTOKON in a simple way as manhour and CPU time (IBM 370\135). A 360,000 tdw tanker is chosen as an example because it permits; discussions during this meeting as it is a type well known by almost all the shipyards present.

\* The information given above concerns mainly employees directly concerned by the AUTOKON activities.



- Date of treatment : August 1974
- Ship sections treated by AUTOKON : the whole ship except the superstructure, seatings, some plane panels
- Total number of AUTOKON parts : 11309
  - Number of different parts treated by AUTOKON : 6628 \*
  - Number of nested plates : 1293
- Number of developed plates,
  - with SHELL 2 : 474
  - manually : 103. (forward and aft endings and wrongly developed plates)
- The number of manhours and CPU time is stated in Table 1 for each AUTOKON module.

· This means that more than half of the parts have been handled twofold by AUTOKON.

TABLE 1

AUTOKON performance for a  
360 000' tdw tanker

AUTOKON programs	Manhours	IBM 370\135 CPU hews
F A I R 2	500	40
LANSKI ( LNGIN	30	6
( YAPIN	106	
SHELL 2	90	
	1012 (control)	7
TEMPLATE	10	1
(C.N.C. version)		
PART CODING	6630	70
NESTING	1500 **	8

\*- This figure concerns the coding of the parts and the Control of computed dimensions

The cipher corresponds to :

- manual nesting of parts
- definition of input data for NEST 2
- control of computer results.

## 5. FINAL REMARKS

After having solved some difficulties concerning the AUTOKON programs and their implementation, it might be stated generally that AUTOKON satisfies the C.N.C. demands, although some problems still remain, such as :

- speeding up the fairing of the body plan
- shell development

The success of the system is based on an easy adaption of the involved persons to the system and its language . The *figures* given in Table 1 show, in our opinion, reasonable expenses in manhour and computer time.

On the other hand, it is believable that the present AUTOKON level at C.N.C. may not be expanded towards a more complex system without postponing the system conception.

HULL SYSTEM AT ITALCANTIERI COMPANY1) INTRODUCTION

(ITC is an old AUTOKON user, as reported in the previous meetings.

Apart from PRELIKON, all the other modules have been largely used in the last eight years.

To complement the functions which are not furnished by A.1, ITC has developed a system, named SCAFO, that solves all the problems related to the shell structures and some related to the internal panelling.

It includes the following modules:

- Frame Table definition
- Primary Inner Structures Loading (panels)
- Shell Landing
- Primary I Structures Landing
- Section Drawing
- Table of Detail (interface SCAFO - A1)
- Body and Shell Expansion Plan drawing
- Shell Expansion
- Templates
- Long . Frame and Transv. Frame expansion (interface SCAFO - A1)
- Jigs, block marking and controlling data
- Bevels offset
- Painting Lines Heights
- Draft Marks

General Base List

In addition to the above principal modules, other programs are available; they give us offset tables for frames, decks, longitudinals and other structures. This system and a large library of A. 1 norms gave us the opportunity of merging Mould Loft and

## I T A L C A N T I E R I

ptical Division with Technical Division. The former were previously in the yards and the latter at Headquarters.

The scale 1:10 was not introduced in the new procedure. Body plans, pieces, nestings and others, are drawn out in scale 1:20. A complete body plan in scale 1:10 is sent to the yard just for checking purposes.

## 2) FUTURE IMAGE OF FULL SYSTEM BASED ON A74

Though A.1 and other modules are working at a good level, they cannot handle automation in the design phase. Drawings with prevailing automatic operation are not possible.

ALKON language and its properties are oriented to solve, quite automatically, such lacking capabilities of A.1. Data base management system provides the necessary tool.

For the time being we are revising the old norms with the ALKON language. They are handled to avoid duplication with A74 basic norms. Courses are scheduled to prepare people in using the language. We'll start with A74 in June 76 with a new cargo ship.

At the same time we have to convert some utility programs working between the SCAFO system and A.1.

Why SCAFO system and not LANSKI and related programs ? After we compared the two, as to number of modules, output quality and computer time, we decided to go on with ours.

Even if it works on a separate data base it brings about much reduction of data volume, and it allows easy maintenance in case of design alterations.

SCAFO data base file organization is made by the catalogue method and the access is random. The data are stored as a form of input image, net intersection ordinates.

According to the experience we have gained on this aspect of ship building we shall give some notes and suggestions that may be worthy of attention.

LANSKI and related modules are not developed according to a unique vision. Different commands and ways of retrieving data may cause some misunderstanding.

### LANSKI

The command BRILL or others, should include also structures such as margin plates, not parallel to the global planes or ship axis.

Scantling of longitudinals must be stored only once, and it should not be redefined in other modules (See LFRAME), CUTO type should be given along the structure as a group and not along the longitudinal.

In drawing a body plan, profile contour with its true length and face plate deviation should be available. (See fig.1).

#### SHEEL

Output should give us further information about the shape, so that rolling, bending and heating operations may be valuable.

Welding shrinkage should be included.

Marking contour refer to template position only (if requested).

Diagonal or other tables to check, after bending, very shaped plates.

#### LFRAME

The module should include also transverse frame because the same operations are performed in the workshop.

Referring to LANSKI notes, scantling and neutral axis should be picked-up automatically from D.B. Table of length along the shell should be calculated also for the raw profile before bending.

#### J I G S

Too much complex input data compared with a very poor output. High computer time.

Further data must be read from other outputs. According to us you need further information to perform the following operations in building blocks:

- Shell plates lying
- Panel marking or checking (See fig.2)
- Longit. and frames inclination
- General checking of boundary (seams, butts) orientation of big structures (by means of theodolite)
- Main references in the dock position.

NESTING AND GENERAL BASE LIST

At present ITC is trying to reduce its operation time in NESTING by means of interactive method with UNIVAC ADAGE; the necessary hardware and software should be available during the months. A group is carrying out the program connected with this side of part coding.

ITC is also working on a system concerning the general base list. Input data have to be prepared from structure data base. Through these output lists, manufacturing information as material handling and naval shop works are obtained.

Until now, we have not examined Aker's norms.

As we know, the package would give us further possibilities in design phase and as a consequence in part Coding.

Bearing above matters and introduction of A74 in mind, we will have to contemplate the future image of the new integrated system in addition to the working modules.

- i) A new module should solve and transfer, into A74 data base, the Primary Inner Structures (may be in an input image), as well as TRABO transfer the body plain.
- 2) The wire model referring to such structures should be available automatically.
- 3) Part identification code system will be one of the most effective and useful methods, so that it can reduce manual input data for general base list, and interactive NESTING operations in piece retrieval would be quite automatic.

The characteristics of the data to be used in the integrated Hull System should be as follows :

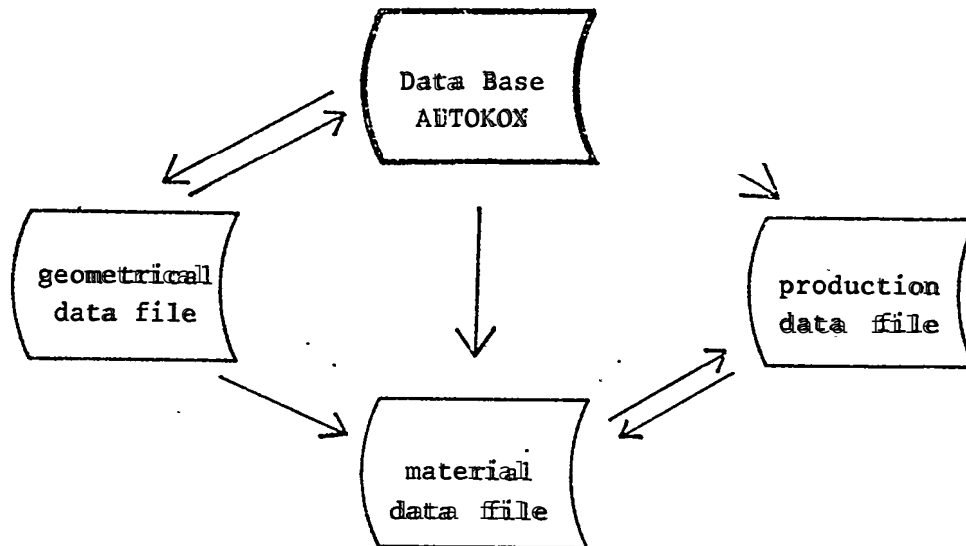
- Geometrical data SCAFO data file
- Design definition data )
- Parts data AUTOKON, data base
- Piece list data
- Nesting data

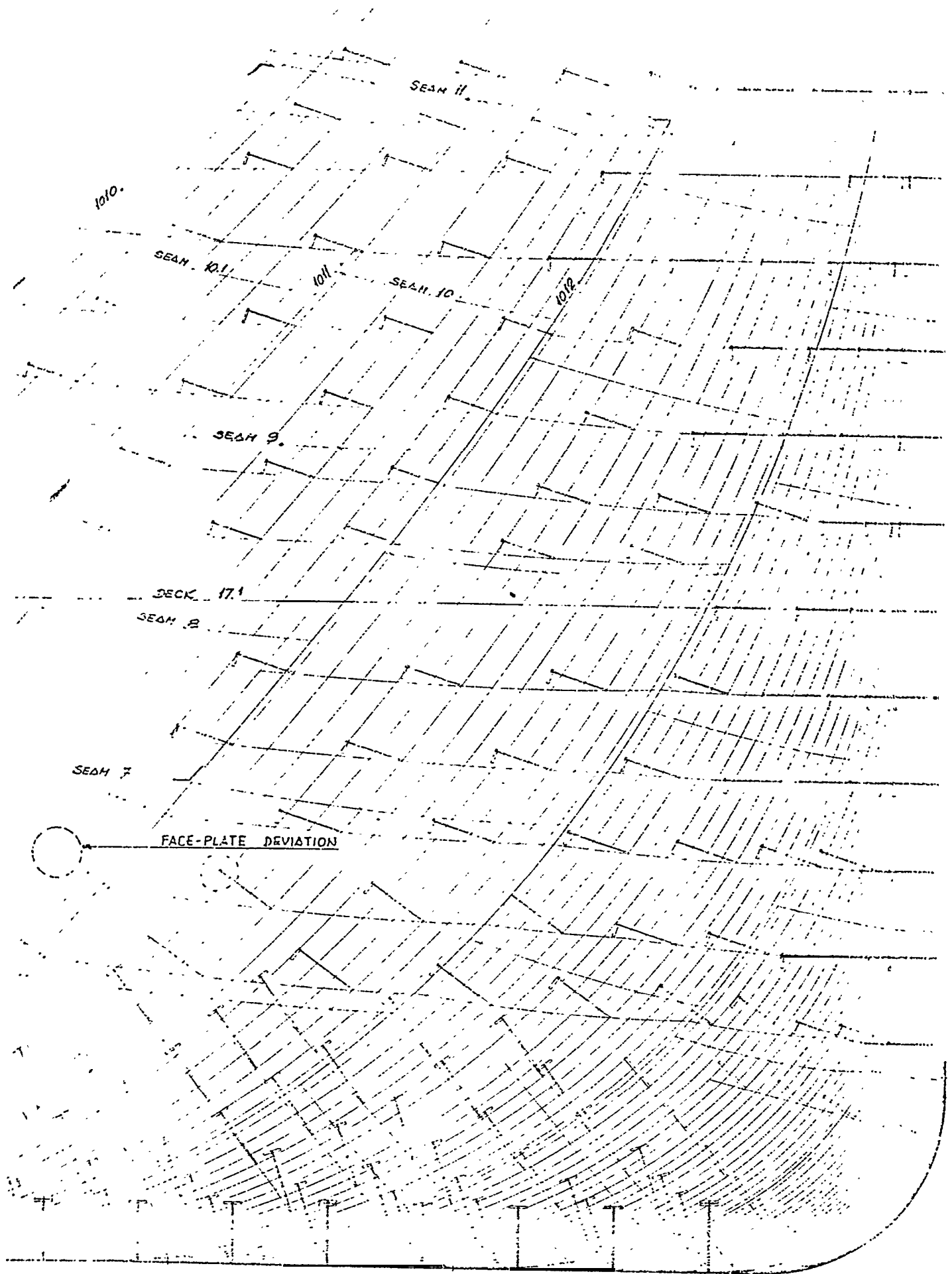


# ITALCANTIERI

- Data for production                      Production data file
- Material data                              Material data file

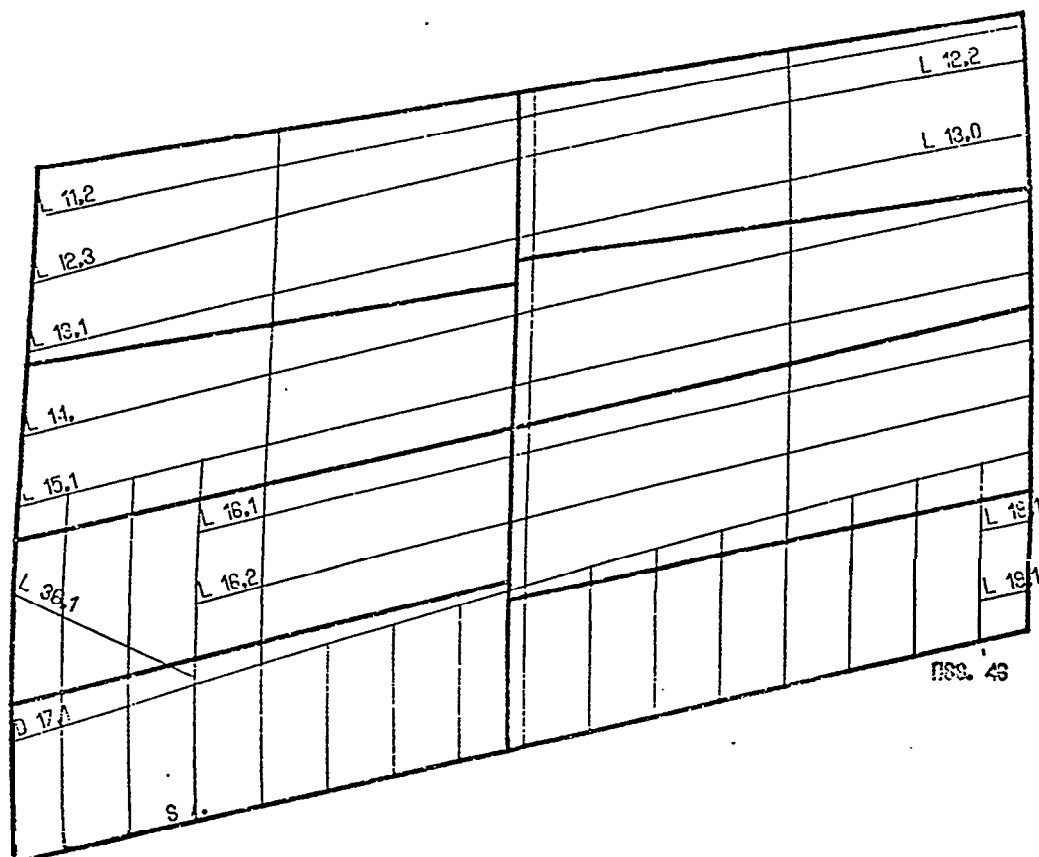
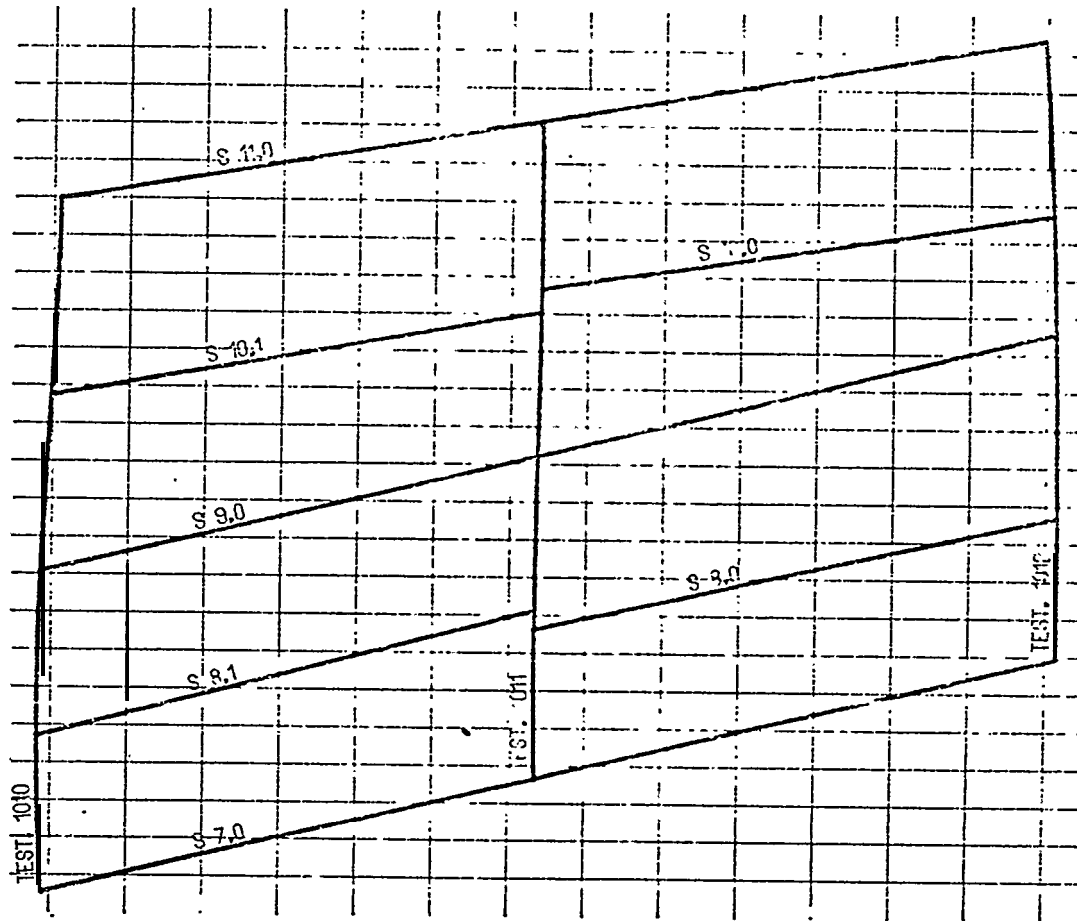
An illustration of the relationship of data files in the integrated Hull System in I.T.C. may be as follows.





# BLUCCO FG32/5

SONLA V 100



DSS. 32

BUILDING BLOCK ON PLATTFORM

fig. 2

### 3) EXPERIENCES AND FIRST APPROACH WITH THE A74 MODULES

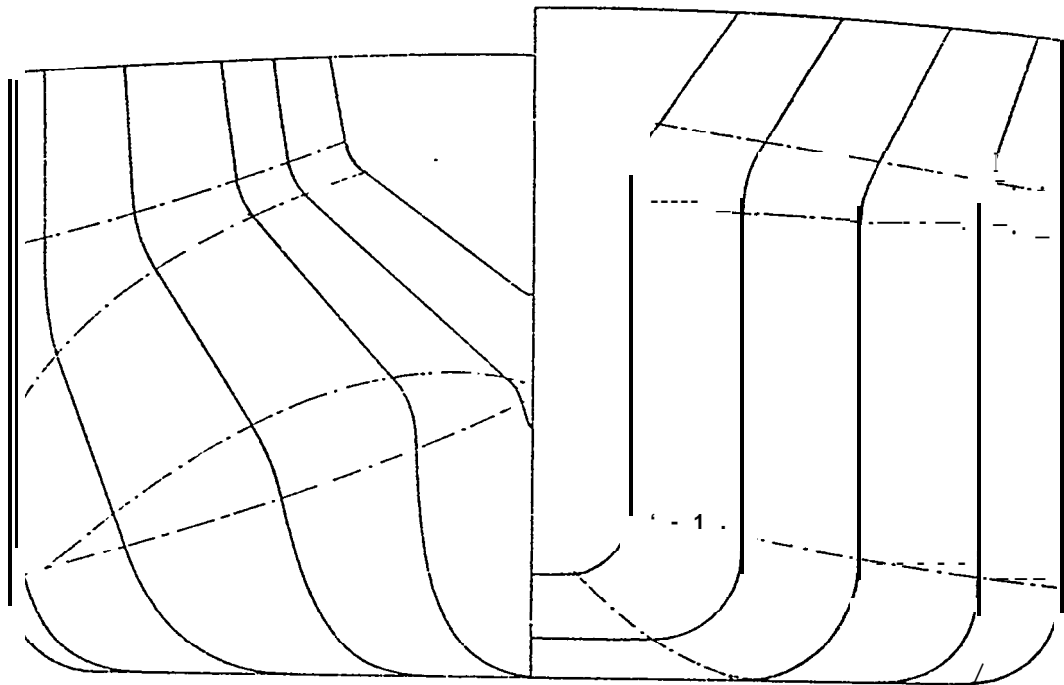
#### FAIR module

FAIR module has been largely used by ITC both for its own ships and those of other yards.

Services for other yards cover fairing and shell structure. The enclosed tables illustrate what has been done in the last seven years . (See tables 1,2).

ITC ships have been treated partially or completely with the other A.1 modules too. From 1972 on, the entire shell area (excluding very shaped stern and stem) is processed by SCAFO system.

By reference to the tables it is brought to mind that in helping the FAIR module we developed some auxiliary programs because some bodies had particular geometrical lines, as follows :



In such types of forms the final body plan is stored both by SERIES via ENAPL and LINGEO1 via output from the mentioned programs.

The tables give us further information about the times re-

## ITALCANTIERI

The ending area of those marked by a star were corrected manually in the mould loft or tec.div. and man hours are not included in the table.

After such corrections, we used to run fairing again, so that we stored the right included lines.

Such procedure occurs only for our own shells.

### Fairing operations

Usually fairing operations are handled by the men. Both afterbody and fore body are treated at the same time.

We try to have the preliminary completed body plan as soon as possible.

It is unimportant whether it is very well faired or not. Anyway enough as a support for design purposes and shell landing.

Our shell landing method requires butts, too.

### Modified FAIR 2

FAIR2 module was modified because of the following limitations:

- Fraction number 3 and .6 not possible
- Low value as a maximum proper frame number (250)
- Problems by using TRABO

The new module requires only one card after TFRS command with the first and the last frame number.

All the other, frames, stations and butts included are retrieved from SCAFO D.B. as well as absolute distances.

Routines STARTS, GLASPS, FINNES were modified. New routine TFFAIR was included. The module can work both in the original and new version.

Recently we have faired two ferries-Part coding is carried out by A.1.

A74 capabilities help to generate transverse frame contours

for the boss of the stem area. Procedures were as follows :

- Body plan obtained by FAIR2
- Generation of new contour according to the boss of the stem by means of A74 ALKON
- Transferring of frames from A74 D.B. to A1 D.B.  
(See fig. n.3)

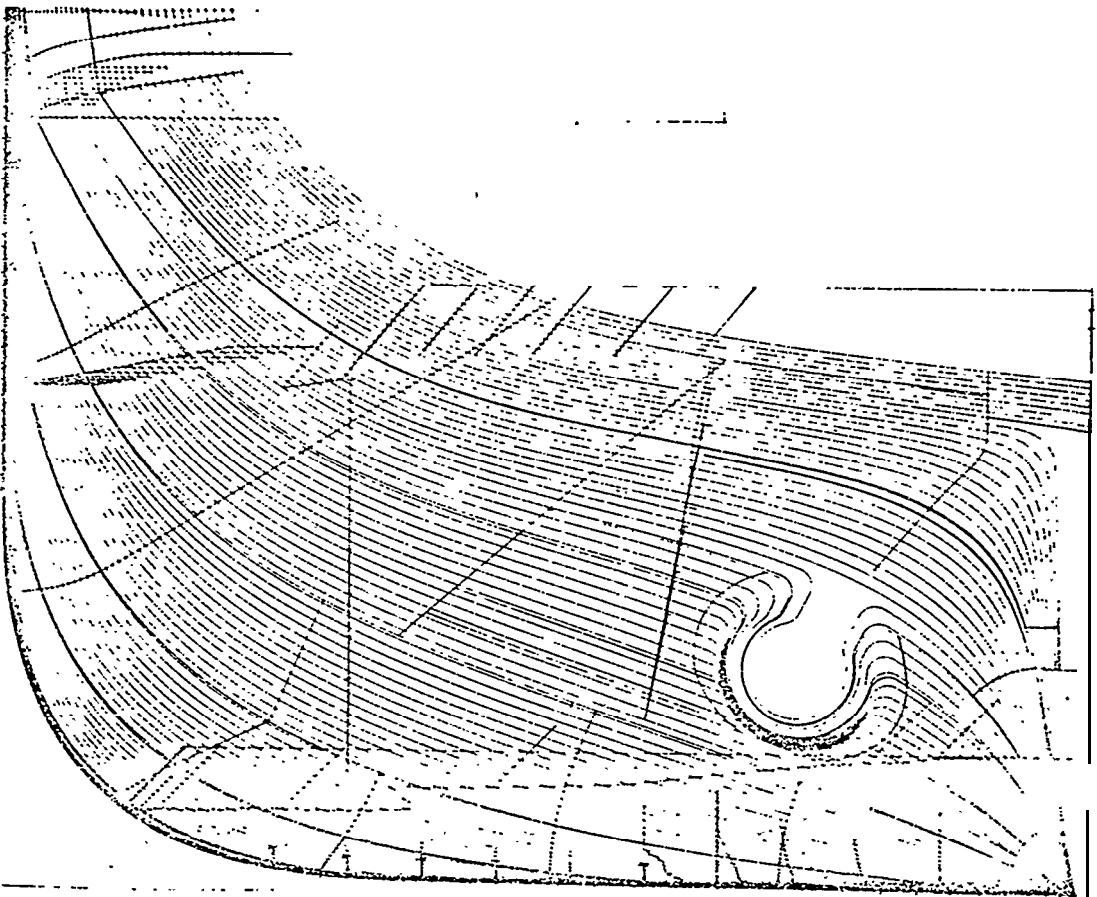
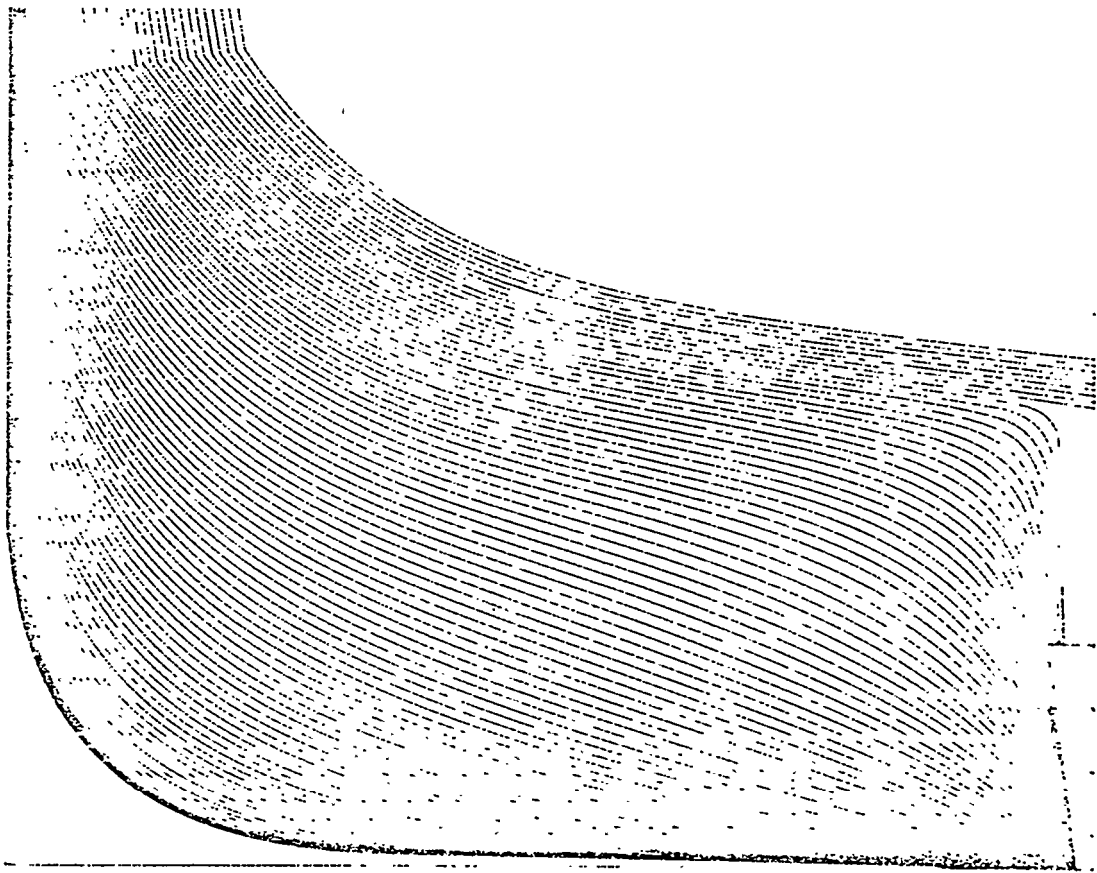
Trieste, 12/2/76

BODY PLANS FAIRED BY ITC

	Company	Date	yn	Type of ship	AFTBODY				FOREBODY				Comment
					days	hours	runs	tfrs	days	hours	runs	tfrs	
	TTC	GEN 69	4242	Container	5	80	3	20	8	95	4	26	Faired by SRS ending area modified by ITC
1	ITC	APR 69	4235	Tanker	18	160	15	164	24	360	30	113	* b
2	ITC	JUL 69	4244	Tanker	20	175	16	172	22	320	25	117	* b
3	ITC	OCT 69	4268	Tanker	13	92	13	92	17	188	18	76	* b
4	ITC	APR 70	4275	Drill vessel	11	62	12	65	12	72	14	82	Auxiliary progr. aid
5	ITC	MAR 71	4276	(4235) "					4	30	5	102	Frames spacing mod.
6	ITC	JUL 71	4279	OBO carrier	12	48	9	112	10	64	16	57	* b
7	ITC	AUG 71	4294	Bulk carrier X 1.2		90	11	107	13	104	14	82	* b
8	ITC	SEP 71	P		17	180	13	48	7	64	6	48	
9	CNR	SEP 71	253	Ore oil carrier	26	249	15	122	12	144	2	87	Auxiliary PCR aid
10	CNR	MAY 72	295	Ferry	17	250	5	58		same shape as AFTB.			Auxiliary PCR aid
11	CNR	JUN 72	297		18	176	19	63	8	113	7	75	
12	ITC	JUL 72	4298	Tanker	17	210	13	205	14	1.35	8	125	
13	ITC	FEB 73	4304	(4244)					4	26	5	107	Frames spacing mod.
	ITC	FEB 73	4284	(4268)	2	12	2		2	12	2		Butts modified only
14	C:w	APR 73	298		17	240	1.2	78	9	140	6	89	
15	MU G	MAY 73	6920	Refrig. s.	9	152	7	100	13	196	16	114	?)

	Company	Date	yn	Type of ship	AFTBODY				FOREBODY				Comment
					days	hours	runs	tfrs	days	hours	runs	tfrs	
16	ITC	JUL 73	4310	Clean p.carrier	13	160	11	85	14	172	14	75	* b
17	ITC	LUG 73	11						3	25	3	70	b Frar.ws spacing md.
18	CNR	AUG 73	279	OBO carrier	18	240	18	98	7	88	3	fil	Auxiliary PGR aid
19	ITC	OCT 73	P		7	35	3	48	8	70	9	38	- " -
20	CNR	DEC 73	300		15,	180	17	81	8	140	5	107	
21	ITC	FEB 74	4320	Tanker	11	98	11	89	13	148	13	95	
22	ITC	MAR 74	4326	(4294)					4	25	4	75	b Frames spacing mod.
23	NCA	MAY 74	103		7	110	10	65	9	103	8	76	
24	MUG	JUN 74	1657	(6920)					4	24	5	30	Bulb modified only
25	CNR	SEP 74	255		15	175	13	120	5	78	4	98	Auxiliary PGR aid
26	NCA	OCT 74	105		12	95	13	145	15	180	16	230	b
27	EUROM	FEB 75	96		10	80	12	75	7	105	7	8?	
28	CNR	FEB 75	550		17	190	18	60	5	60	6	55	
29	MUG	APR 75	1658	Refrig. s.	8	120	7	100	11	180	13	116	b
30	ITC	JUL 75	4340	FerRy	8	90	9	67	15	130	11	80	* b
31	ITC	CCT 75	4345	Ferry	9	70	11	87	13	112	10	104	* b
32	ITC	OCT 75	4343	Tanker	12	90	10	95	20	160	12	71	* b
33	ITC	GEN 75	4347	Ferry	18	150	8	83					* b





USER'S GUIDE TO THE NORM PACKAGES

CONTENTS :

- A. Introduction
- B. Presentation of the norm packages.
  - B.1. The fundamental idea of the packages.
  - B.2. Using a norm package.
  - B.3. Integrated use of the packages.
    - B.3.1. Various approaches.
    - B.3.2. Flowchart of in-and output.
    - B.3.3. The steps
- C. Data and datastructure.
  - C.1. Autokon database.
  - C.2. Representation of data.
  - C.3. Wiremodel.
  - C.4. Main data tables (matrices) .
  - C.5. Standards.
- D. Design and Production.
  - D.1. Datastructure in design.
    - D.1.1. Composition matrix.
  - D.2. Datastructure in production.
    - D.2.1. Composition matrix, Position matrix, Production data matrix.
- E. Examples of use
  - E.1. Specific problems.
  - E.2. Examples for each package.
- F. Alphabetic list of the norms including purpose.
- G. Key-word reference to norms and norm packages.

## A. INTRODUCTION

The objective of the Autokon system may shortly be said to be to enable the user to describe in large detail the entire steel structure of a ship or other structure in the database, and extract a variety of design and production data.

Steel  
information  
system

It should in other words be a "drawing generator" (including information for NC-cutting) but also produce material lists, weight calculations etc. To- fulfill "these tasks the present system of routines called norms play an important role.

.. The basis of the present system of norms rests with ALKON, a problem oriented computer language. It is necessary to know some of the basic properties of this language in order to understand the norm system:

It maintains a dialog with the Autokon database.

It has very extensive features for describing plane geometry.

It is general in nature and may be used to store various types of information on the database.

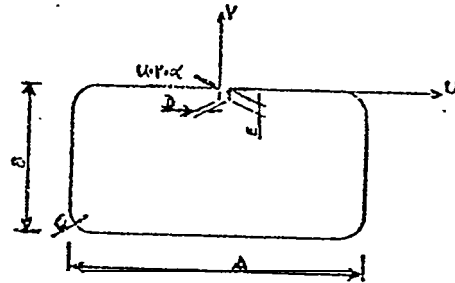
Various data structures may be defined by the user.

An ALKON manuscript may be stored temporarily (REP) or permanently (NORM) on the database

A description of the use of the language itself is given in the ALKON Users Guide.

The last mentioned property is the key feature which enables advanced commands to be built up in the AIXON language, commands called NORMS,

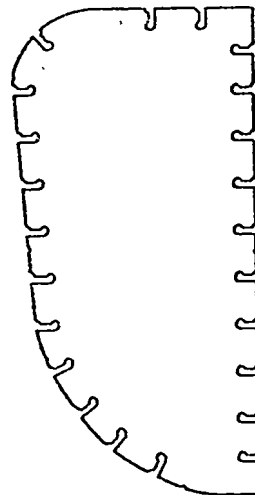
An example of a simple norm is a hole of a certain shape, but with variable parameters (hence the word norm) .



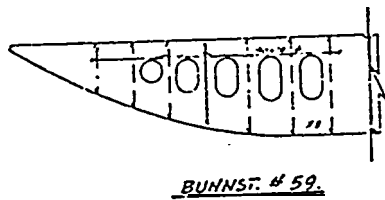
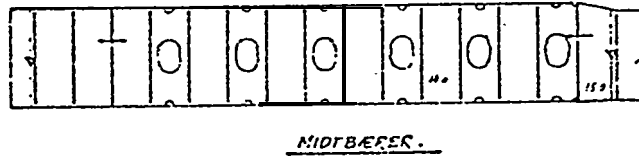
CALLING SEQUENCE

HOLE 101 (u+v+C +A+B+C+D+E)

Examples of more complex norms are those building up a complete numerical description of all cutouts for longitudinals through a bulkhead:



And those defining, floors and girders in the double bottom:



Presently the library contains between 600 and 700 norms, most of them written according to 'a philosophy. This..Useres Guide will try to explain the philosophy and also give some practical examles in the use of the system. It also gives some basic information which the user needs in order to understand the tool" he is using.

## B. PRESENTATION Of THE PACKAGES.

### B.1. THE FUNDAMENTAL IDEA OF THE PACKAGES.

Total  
definition  
of structure

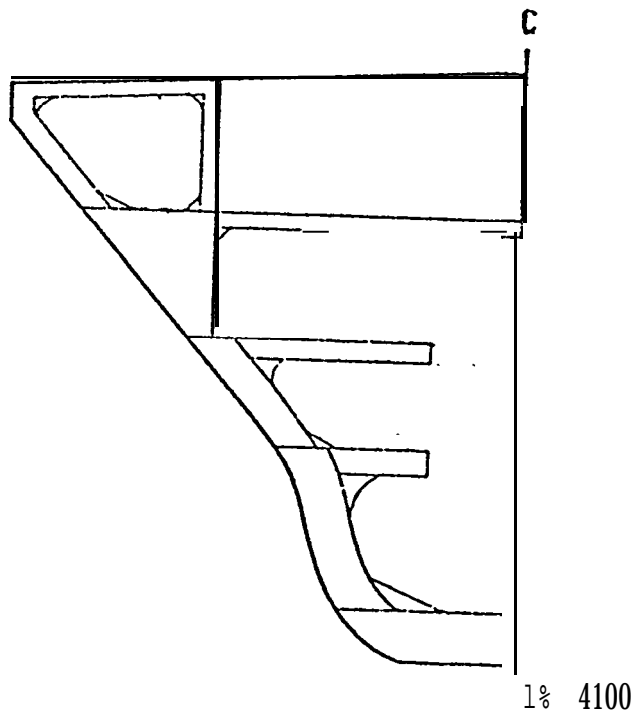
As mentioned in the introduction, the main objective of Autokon is to build a full description of the scantlings of a steel structure and to utilize this as an information system giving drawings, material lists, weight estimations etc. In this picture, the norms deal with the internal structure (excluding the shell and the Longitudinals on the shell).

Break down  
into smaller  
units

Logical tasks

This is quite a big task and to fulfill it required a large number of norms. Thus, to obtain complete knowledge of the system required a lot of time and practical use. It was therefore considered essential to break the system down into smaller more easily understood units. These units represent logical tasks to be performed, and very often they are also related to some specific location in the structure. The total objective of the norm system may thus be achieved using the packages as building blocks .

An example of such a building block is the package dealing with web-frames in the engine room.. The final result after going through a number of steps is drawings of web-frames.



## B.2. THE USE OF EACH NORM PACKAGE. # .

Each package boils down to being a description of how a number of norms are used in sequence to obtain a result within the specified framework. The number of norms used in each specific case may vary for the same package. A further description of each package is given in B.4. and in the Users Guide of each particular package.

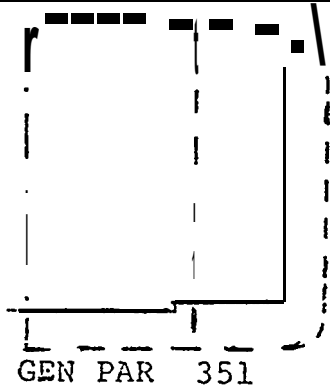
### Generality

An important point regards the generality of the system. Two methods have been used to take care of this.

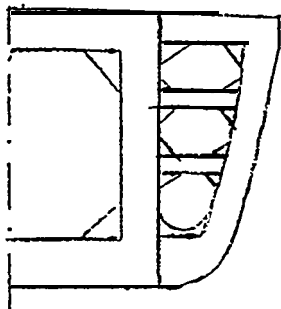
### Levels of norms

1. Some of the packages deal with the steel structure at different levels, the higher level norms being more specialized. These tend to depend more on constraints imposed by the actual geometry of the structure. One example is found in the package of web-frames in tank area.

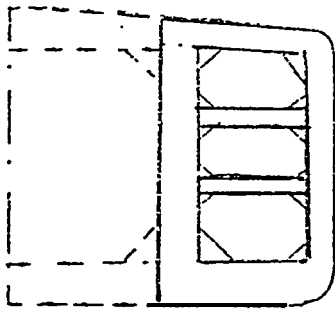
Norms in the tank area.



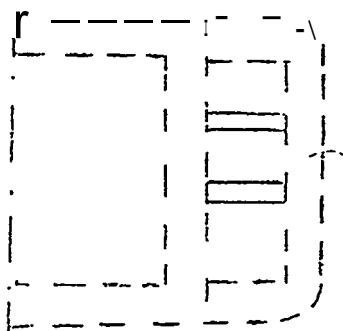
GEN PAR 351



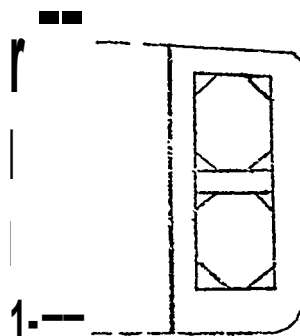
WEB 360



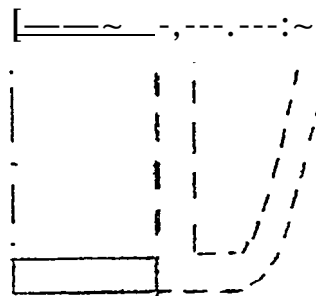
WEB 362



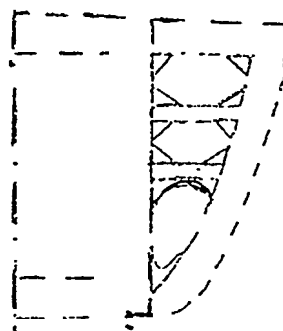
Wm 353



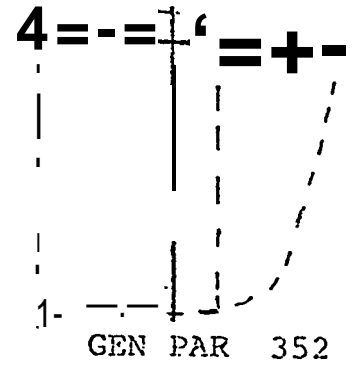
WEB 370



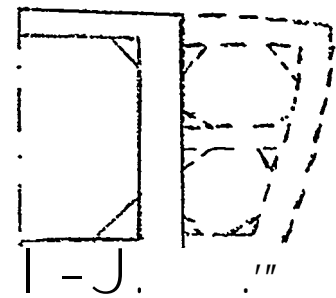
WEB 351



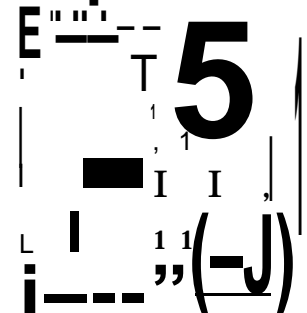
BKT 355



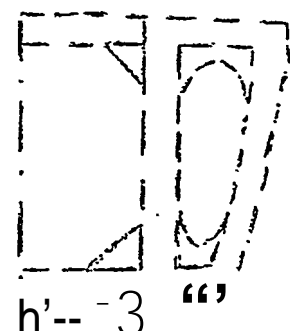
GEN PAR 352



WEB 361



WEB 352



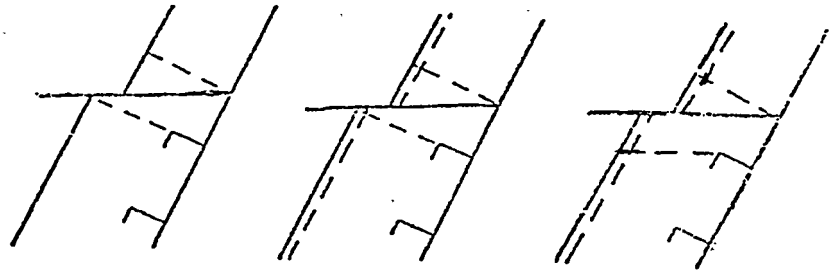
BKT 360



Modification  
of packages

The point is that in this case WEB 360 uses a number of other norms as subroutines. At the lower levels the norms are increasingly general. If your construction differs from possible variations within a package, the higher level norms may be modified or rewritten, still using the lower level norms.

2. The other solution is represented by the package of local stiffening. In this a rough picture is built up initially. this is then modified until the desired result is obtained.



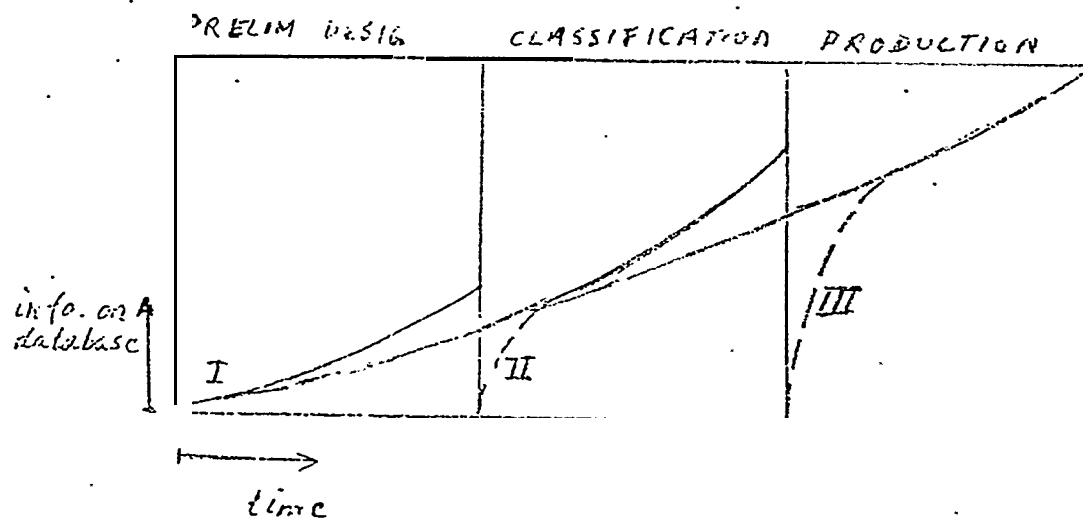
Examples of how you may design your own packages are given in chapter E.

### B.3. INTEGRATED USE OF THE PACKAGES.

#### B.3.1. VARIOUS APPROACHES.

One of the main difficulties for a user is to get a general view of the system. As mentioned the packages play the role of building blocks sometimes cemented together by system norms.

Before proceeding to describe the various steps, the user should realize that the system may be used in various ways:



The fig. illustrates three different utilizations:

1. The system is used from early design, the database being gradually updated and fed new data.

FILIP  
prelim.  
bodyplan

The early steps may be done using a preliminary body plan (may be generated by the program FILIP). The system will produce early layout drawings for further evaluation of strength, layout and construction problems. Drawings will not contain detailed information.

11 The procedure is started in classification, preferably using the final bodyplan.

The procedure is roughly the same, but the amount of details like local stiffening is

of drawings to be manually furnished with text, measurements, identifications etc.

Key data like points and angles may be extracted for production **planning**.

Class.drawings  
prod.information  
material lists

Material (stiffener) lists may be extracted depending **on** the amount of detail which has been put in.

111 The actual design of a ship is in some cases done by others, and classification drawings simply supplied as part of the deal. In this case data which is normally input to the production phase may be generated quickly at the start of this phase.

Quick generation  
of data usually  
available from  
Classification

Note that the amount of work involved is significantly less than that of going through the entire classification procedure. This is mostly due to the fact that part of the work at earlier stages is concerned with output.

B..3.3. 'THE STEPS . .

In the description of each step, **some** comments will be given regarding the main approaches outlined in B.3. 3.1.

Building  
frames

- a. The initial input consists of a set of faired building frames and preferably also stem, stern and deck contours (The latter may be generated by norms if they are not available) .

TRABO

The input to Autokon database is performed by the program TRABO. (Further description of contours are given in ALKON Users Guide). Take care to obtain the correct location of origin.

- b. This step involves establishing some main parametric tables.

-ROUT 1 always runs immediately after TRABO.  
If TRABO is run again so is ROUT 1.  
The norm establishes condensed frame table in record class  
(3+7+1023+7+1023+3)

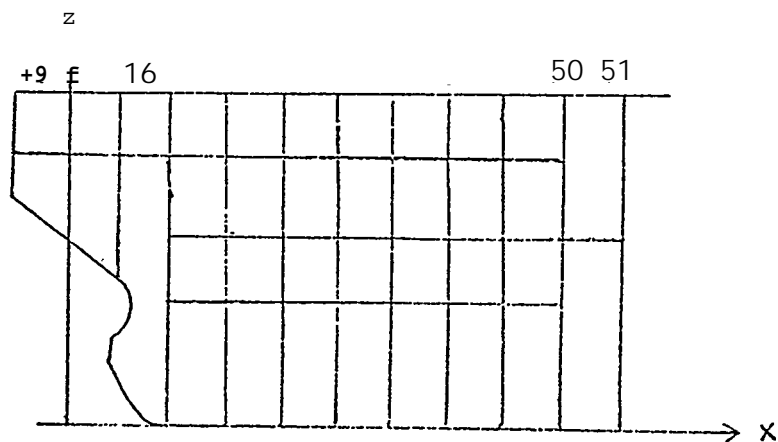
Main ship  
parameters

-Height of stringers, platforms and in some cases decks are defined by norms in GROUP 10. This information is later used by the norms STRINGREF, PLTHH and DRHT.

c\* Definition of the main stiffening.  
 (Note that double.bottoms are taken care  
 Of by two nearly selfsufficient packages) .

Dimensions of  
 transverse  
 frames

- Properties of the transverse frames are  
 described in the x - z projection.



This regards both Webframes and ordinary  
 profiles.

The description is stored in the Midem.  
 format (see C.4] and includes the dimensions  
 of each frame (these may vary between  
 different decks etc.) and wether the thickness  
 of a frame is aft or forward of the reference  
 line etc.

The norm used is GENMIDEM 1 of GROUP 1

```

#
NEW ARUF: PERM ARUF:
DECK(1)
GEN MIDEM 1(+ARUF+13
+13      +31  +13      +4440      +UD0      -1  +360002
+13      +34  +0       -UD0      +UD0      -1  +360002
+13      +37  +0       -15540     +15540     -1  +360002
+16      +37  +13      +15540     +UD0      -1  -20
)
FIN CONVID(+R+13+ARUF)
&
13=web      frame no. sym.      V start.      V end.      below      plate
16=bulkh.                                     deck      thickness.
! if standard profile

```

profile dimension  
Line 2 in Tabel 36  
in record(1,4,2,0,0,0)  
made by ROUT 415.

This information is later used for generation of the actual web--frames (G1%3L!}? 3[, 4) and also for weight and center of gravity calculations if the frame consists of a standard section (profile) like HP or flatbar etc.

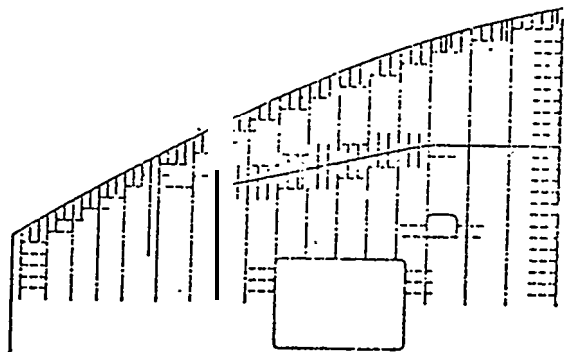
Deck  
stiffening

-The stiffening in the deck-planes should be described next. (GROUP 1). Again the MIDEM table (Minor DETail Matrix) is used for the description in the database, though a variety of norms are used according to task. The full description is given in the package for "Generation of deck planes" (GROUP 1)

Information  
used for  
web-frame  
drawings and  
for augmenting  
contours

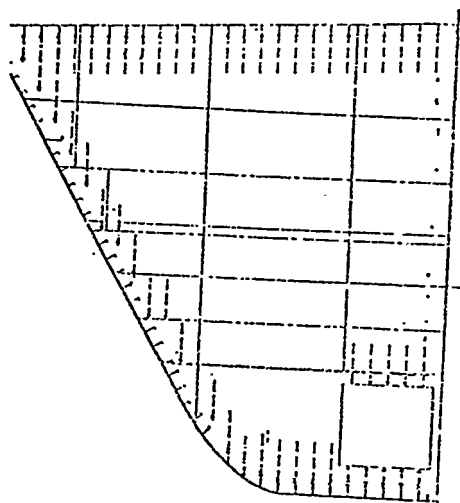
As for transverse web-frames in X-Z projection the information is later used for the generation of the actual web-frames, and the longitudinals are used for augmenting contours in the transverse plane.

An example of possible drawing output is shown in the fig.:



The package is general in that nearly all types of stiffened panels may be arrived at.

- Stiffening on transverse bulkhead (GROUP1.2)  
,Similar to deck planes.



- d. Definition of main structures.  
Concerns web-frames and stringers.

**-Web-frames:**

Three main  
Configurations  
each with  
many variations

Three main types are supplied. which are "typical  
for engine room, tank area and forepeak.  
Each yard number should, however, be inspected  
to find out where each of the packages may be  
used . The package for the engine room may for  
instance in many cases be used all through a ferry.

GROUP 3: Forepeak

GROUP 4: Engine room.

INPUT : Uses the information generated by GROUP 1  
regarding transverse frames and deck-  
beams.

Parallel  
contours -  
PCONS

OUTPUT: Contours in "wire-model" (see C.3).  
This concerns in particular parallel  
contours which constitute the inner  
boundary curves of the web-frames. These  
contours are used in production for actual  
"production parts;" drawings of entire  
web-frames. If starting off in production,  
this last point is of course irrelevant.



GROUP 6: Web-frames in tankarea.

INPUT : Only the body plan.

W this case information about  
dimensions of frames is given in the  
norms.

OUTPUT: As for GROUPS 3 & 4.

-Stringers:

Two packages are supplied.

GROUP 2: Stringers in forepeak

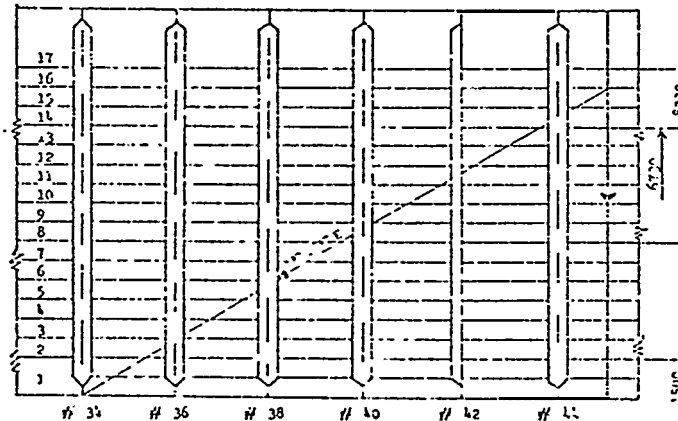
GROUP 12: Stringers in tank area.

INPUT : Information about stringers generated  
by GROUP 1 ( GROUP 12! .

This regards both stringers on bulkhead::  
and on the shell.



Input to this package is information about  
longitudinals previously generated by GROUP 1.

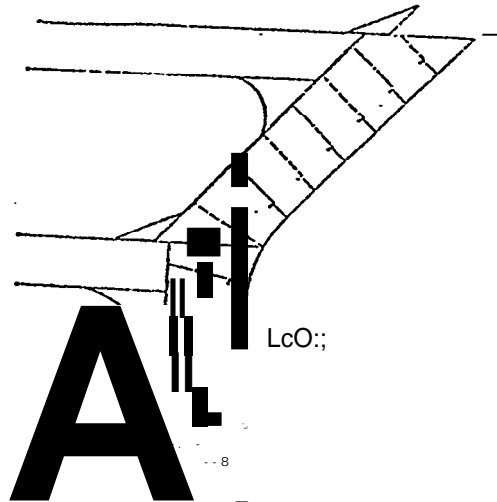


GENACON

- The next step is simply to produce the actual contours using GENACON norms. These norms will fetch the standard cutouts from the norm library.
- The norm GENACON 800 is available to produce augmented deck contours at shell directly on basis of the MIDEM of transverse frames in the X-Z projection (paragraph c)

#### e. Local stiffening.

One package, GROUP 14 is designated to deal with the problem of local stiffening at web-frames and brackets. For the former, an initial solution may be obtained automatically using the information about longitudinals.



See also the package concerned.

Note, however, that the main significance of this package is obtained by introducing Standard Details (paragraph f.)

#### f. Divide/Standard Details

This box in the flowchart concerns obtaining the actual "production parts", i.e. single plates.

There are three main procedures involved, of which only one is described in a specific norm package (if using a Standard Details)

Note again that parts in the double bottom are treated slightly different and are dealt with in paragraph h.

1. Parts are generated by ALKON or specifically designated NORMS or REPs on basis of previously generated contours. A web-frame part for instance is generally limited by an ACON, a PCON and two seams consisting of straight lines.

In ships where many parts in the structure are of similar type this is a very efficient method . This procedure is more typical for parts on web-frames and stringers than for parts in large stiffened panels.

2. This method consists of subdividing large, previously defined design parts. Norms are supplied for subdividing both parts (DIVIDE norms) and stiffening information.

DIVIDE  
GENMIDEM 850

The design parts may have been generated by norms described in paragraph c where these can handle 7'icons (if needed) .

Note that this procedure is under revision and that some norms are now available in GROUP 18 (Datastructure in production) which handle the transition from Design to Production in a more standardized and simpler fashion (FIN11,2 - FJX114j)

- 3 . Smaller parts like brackets etc. may be generated as Standard Details. Brackets on web-frames (GROUP 14 - Local Stiffening) and brackets under decks along shell. OK other longitudinal structure (GROUP 1) , have been previously defined in MIDEM format (paragraphs b and c).

Standard  
details,  
GROUP 19.

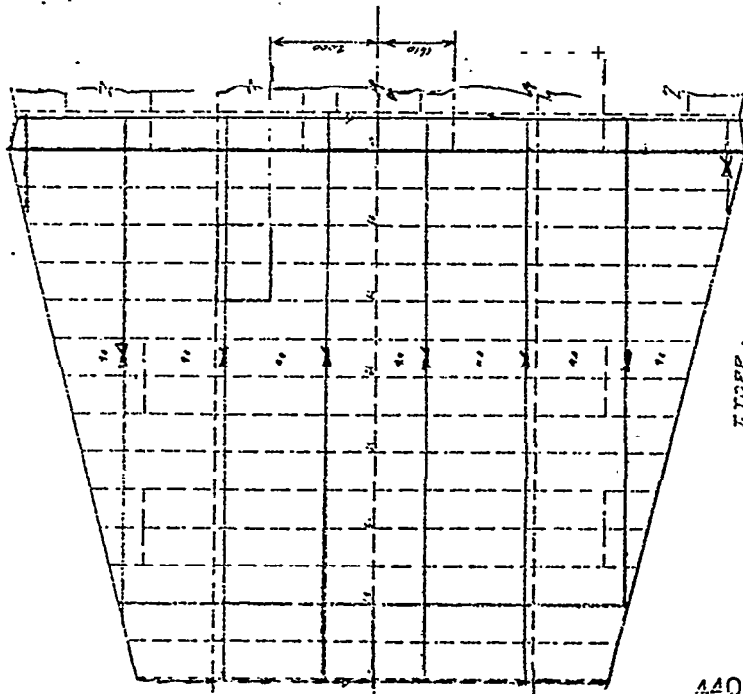
Using GROUP 19, information on type of detail may be entered in. the MIDEEM which will then contain sufficient information for the part to be generated automatically.  
. See also Book of Standard Details.

g. Double Bottom in Design.

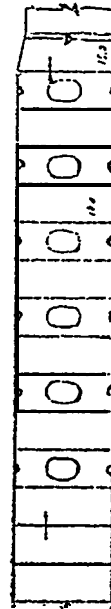
The task of defining the double bottom structure in design is taken care of by norm-- GROUP 11, to which may be referred. The **main input** to this package is defined. as in the tank-top plane (concerns girders, floors, holes etc..). The package contains features for avoiding contradicting information.

The output consists of double bottom drawings of a standard which after adding text etc. is also suitable as "production drawings".

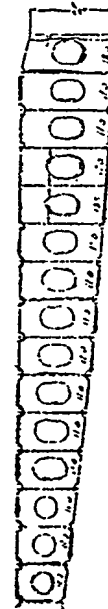
Illustrative "check and coordination" drawings may also be generated.



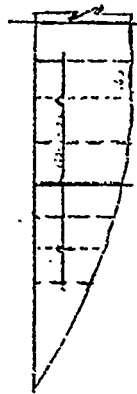
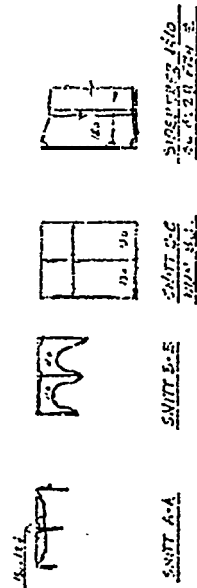
440



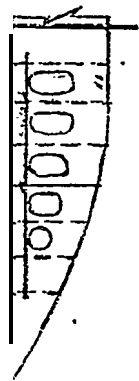
STIFFENER



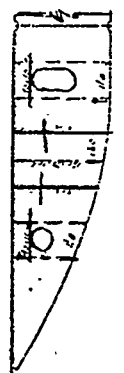
STIFFENER 2890 FRA



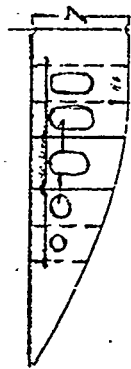
BUNNST. # 60.



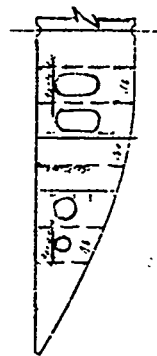
BUNNST. # 59.



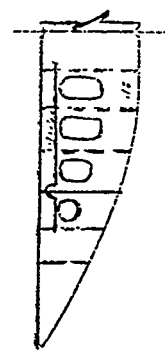
BUNNST. # 58.



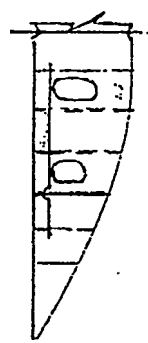
BUNNST. # 57.



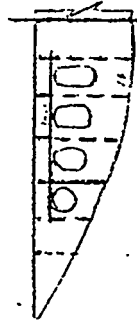
BUNNST. # 56.



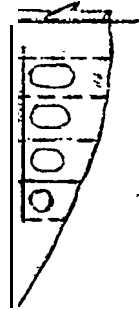
BUNNST. # 55.



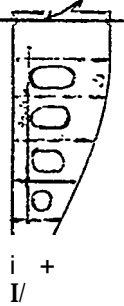
BUNNST. # 54.



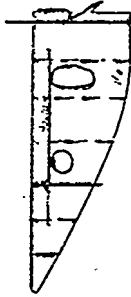
BUNNST. # 53.



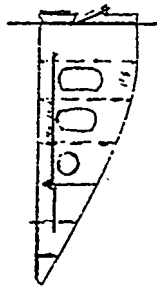
BUNNST. # 52.



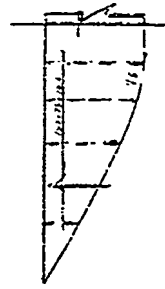
BUNNST. # 51.



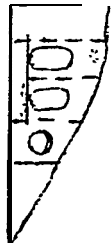
BUNNST. # 50.



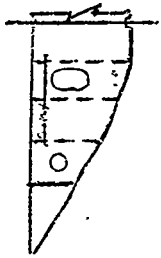
BUNNST. # 49.



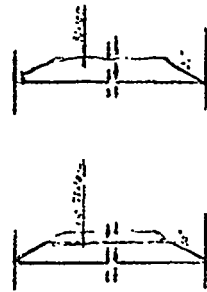
BUNNST. # 48.



BUNNST. # 47.



BUNNST. # 46.



DETAIL OF STIFFENER

SHEET NO. 1 OF 1		749-223-604 749-223-604
PROJECT NO. 749-223-604		

#### h. Double Bottom in Production:

The detailed information available from the design package makes it possible to extract production parts semi-automatically. This is done by norm-GROUP 16. Information to be added concerns margins for weld-shrinks.gc, notches and serial. number of each part.

#### i. Datastructure in Production.

This package (GROUP 18) contains the norms necessary to update and maintain the data-structure in production. The norms are important because the possible output hinges on this structure. The Users Guide for the package itself is necessary reference for a description of the structure.

See also chapter D.2.

Note that shell plates (from SHELL), longitudinal frames (from LFRAME) and transverse frames (see paragraph b) as well as all ALKON defined parts and stiffening are included.

Detailed material lists as well as weight and center of gravity calculations may be obtained for assemblies, subassemblies at any level (panels) or single parts.

Drawings may be obtained for entire assemblies or single planes within an assembly.

Note that the Datastructure is important, though not essential for input to INTERACTIVE NEST



## LISTING FOR:

ASSEMBLY 2385 -SUBASSEMBLY -LEVEL 1

MSFACE=MAJORSURFACE;-FIRST PART=RID2 AND LAST PART=RID3; R FRACTIONAL FRAME NO.

OCSIWPM2TSI

VIS	QUAL	DIMA	DIMB	DIMS	DIMT	DIMC	DIMU	POS	STYP	ETYP	LGHT	MASS	M S F A C L I	SIDE	
20		220	42	11.0	.0						MM	KG			
								6	1	1	5660	138	2 116.00	PORT	
TOTAL LENGTH AND WEIGHT :											5660 MM	138 KG			

VIS	QUAL	DIMA	DIMB	DIMS	DIMT	DIMC	DIMU	POS	STYP	ETYP	LGHT	MASS	M S F A C L I	SIDE
20		220	41	10.0	.0						MM	KG		
								7	1	1	5660	129	2 116.00	PORT
								8	1	1	5660	129	2 116.00	PORT
								9	1	1	5660	129	2 116.00	PORT
								10	1	1	5660	129	2 116.00	PORT

\*\*\*\*\*

## LISTING FOR:

ASSEMBLY 2385 -SUBASSEMBLY -LEVEL 1

LOCATION OF ORIGIN: X-VALUE 60.000 " FROM AP Y-VALUE .000 M FROM CL Z-VALUE .000 M FROM RL

MSFACE=MAJORSURFACE; 1ST.PART=RID2 AND 2ND.PART=RID3 OR : FRACTIONAL FRAME NO.

## DESIGNPARTS:

POS/PART	AREA	THICK	MASS	MOY.Y7	MOY.Y2	MOY.X7	TCG	TCG	WCG	M S F A C L I	SIDE	
	CM <sup>2</sup>	MM	KG	KPM	KPM	KPM	MM	MM	MM			
PLATE1	I	5.14	12.0	493.1	2934	1634	1770	5.97	3.25	3.55	1 39.00	PORT
PL+STIFF.			600.3	3619	1968	2152	5.97	3.25	3.55			
PLATE1	II	4.35	12.0	410.5	3285	1234	1515	7.07	2.89	3.59	1 40.00	PORT
PL+STIFF.			525.4	4143	1522	1691	7.07	2.89	3.59			
PLATE1	3	3.93	12.0	377.7	3602	939	1451	9.77	2.42	3.70	1 41.00	PORT
PL+STIFF.			480.2	4692	1162	1817	9.77	2.42	3.70			
PLATE1	Zb	.12	10.0	9.7	56	25	57	5.73	2.60	5.84	1 39.00	PORT
PLATE1	II	.14	10.0	11.0	17	49	37	1.55	4.40	3.40	1 39.00	PORT
PLATE1	12	.13	10.0	10.5	11	45	23	1.57	4.29	2.20	1 39.00	PORT
PLATE1	13	.22	10.0	17.8	8	75	24	.43	4.15	1.52	1 39.00	PORT
PLATE1	9	.07	10.0	5.7	44	15	51	7.07	2.02	6.05	1 40.00	PORT
PLATE1	1b	.12	10.0	9.6	47	37	33	4.85	3.04	3.40	1 40.00	PORT
PLATE1	15	.12	10.0	9.6	20	43	21	2.05	4.42	2.20	1 40.00	PORT
PLATE1	10	.05	10.0	6.6	63	13	40	9.61	1.95	6.05	1 41.00	PORT
PLATE1	17	.11	10.0	8.9	74	28	46	6.31	3.12	5.20	1 41.00	PORT
PLATE1	19	.11	10.0	8.9	74	27	50	6.23	2.99	3.40	1 41.00	PORT
PLATE1	16	.09	10.0	7.5	38	20	23	5.43	3.76	1.76	1 41.00	PORT

PLATE TOTAL	14.75		1294.1	10557	4156	5094	7.40	3.00	3.60		
PL+STIFF.TOTAL:			1715.6	12209	5035	6210	7.51	2.93	3.62		

TOTAL WEIGHT OF THE ABOVE ASSEMBLY 1.72 TONS

TOTAL CENTER OF GRAVITY IN RELATION TO CHOSEN ORIGIN: X-VALUE 7.51 M Y-VALUE 2.93 M Z-VALUE 3.62 M

j. output fuinctions:

The general norms involved in this are contained in two packages, GROUP 5 for drawings and GROUP 20 for list output.

Note that in some cases there are also output-functions contained as part of other packages if the norms are special to this group only.

HELPL KEYWORDREFC

ELT007 RL70-1 05/08-11:37:05-(0,)

000001	000	MAIN ENTRY	SUB ENTRY	REFERENCE	COMMENTS
000002	000				
000003	000				
000004	000				
000005	000	LONGITUDINAL FRAMES AT SHELL			
000006	000				
000007	000		ANGLE CALCULATIONS	ANGLE2	ANGLE FOR CALC. OF CUTOUT HEIGHT
000008	000			ANGLE4	ANGLE RELATED TO BRACKETS ON LONG.
000009	000			ANGLE5	MOUNTING ANGLE FOR BRACKET
000010	000			ANGLE6	ANGLE RELATED TO BRACKETS ON LONG.
000011	000				
000012	000		CONTOURS,AUGMENTED	MAIN ENTRY	
000013	000				
000014	000		CONTOURS,GENERAL	GENCON100	LONGITUDINAL CONTOUR IN PROJECTION OF LONGITUDINAL
000015	000				
000016	000				
000017	000		CUTOUTS	MAIN ENTRY	
000018	000				
000019	000				
000020	000	LONGITUDINALS,INTERNAL STRUCTURE			
000021	000				
000022	000		DEFINITION m	GROUP1 ETC.	
000023	000			GENMIDEM0	GENERAL
000024	000			GENMIDEM3	FOR TANKTOP
000025	000			GENMIDEM811	GENERAL - ENTRY FOR ENDINDICATORS
000026	000			GENMIDEM2	ENDING LONGITUDINALS AT SHELL/AFT
000027	000			GENMIDEM10	ENDING LONGITUDINALS AT SHELL/FORE
000028	000			GENMIDEM480	ENDING LONGITUDINALS AT LONGITUDINAL BULKHEAD
000029	000				
000030	000			GENMIDEM850	DIVIDE LONG. OR REMOVE PARTS FOR HATCHES
000031	000				
000032	000				
000033	000		CONTOURS*AUGMENTED	SEE ALSO GROUP7	
000034	000			GENACON10	CONTOURS AT DECK5
000035	000			GENACON20	CONTOURS AT LONG. BULKHEADS
000036	000				
000037	000		CUTOUT TABLES	GROUP7	
000038	000			GENCUTTAB0	TABLE OF CUTOUTS RELATED TO MIDEM
000039	000				
000040	000		DETAIL TABLES	GROUP7	
000041	000			GENTAB100	INTERMEDIATE DETTAB
000042	000			GENTAB101	SORTS AND MERGES INTERMEDIATE DETTAB
000043	000			GENTAB102	DETAIL TABLES AT DECK SEE GENTAB100
000044	000			GENTAB103	DETAIL TABLES AT BULK SEE GENTAB105
000045	000			GENTAB103	DETAIL TABLES AT BULK SEE GENTAB105
000046	000			GENTAB104	SORTS AND MERGES INTERMEDIATE DETTAB
000047	000			GENTAB105	GENERATES TABLE OF DETAILS FOR DECK5 OR LBULKS
000048	000				
000049	000				
000050	000		CUTOUTS	MAIN ENTRY	
000051	000				
000052	000				
000053	000	PARALLEL CONTOURS			
000054	000				
000055	000		GENERAL	GENPAR1	PARALLEL TO LIFTING CONTOURS
000056	000			GENPAR850	MODIFICATION FOR BRACKET SHAPE
000057	000			GENPAR808/889	STRAIGHT LINE APPROXIMATIONS
000058	000				
000059	000		FOREPEAK	GROUP3	
000060	000			GENPAR461	TRANSVERSE FRAME AT SHELL
000061	000			GENPAR461	TRANSVERSE FRAME AT DECK5



AUTOKON USERS CLUB MEETING

LA CIOTAT/BANDOL 11.12 M4Y 76

PAPER PRESENTED BY C.A.

J.P. BOISSARD

ALKON FROM LAY-OUT TO PRODUCTION ON THE  
=====

EXAMPLE OF A DOUBLE-BOTTOM  
=====

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\* \*

I - INTRODUCTION -  
-- == -- == -- == -- ==

This paper concerning the evolution of the use of ALKON at C .A. is the fourth presented at the occasion of an AUKKON Users Club meeting.

This time, we have chosen to present a concrete application of what a set of ALKON norms, when directed to a specific part of the ship structure can achieve.

The part of the ship concerned is the double-bottom, both in engine room and in cargo area.

The ship is a container ship convertible into cargo ship ordered in October 1975 and for which keel laying will take place beginning of 1977.

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-X -X

11- GUIDELINES AND MAIN STEPS -  
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As we have already outlined in the introduction, the "DOUBLE-BOTTOM" is one specific part of the ship structure for which one can easily imagine that an AI.KON norm (or set of norms) can be applied.

The reasons which make easy the design by norms of a double-bottom are the following :

- 10) A double-bottom is a well delimited part of the ship-structure

It is composed of :

Shell-plating between two boundary transverse-frames

Tank-top plating including holes, openings or casings between the above transverse limits

Girders running longitudinally including holes and stiffeners

Floors in transverse frames, crossing girders, intercostal or not, including holes and stiffeners

- 20) A good "picture" of the complete double-bottom can be obtained from above i.e. looking at a horizontal projection of the tank-top.

Starting from these facts the guidelines of a double-bottom set of norms will be :

Generation of tank-top, based on the principle of giving maximum information concerning the underlying girders and floors

Approximate positioning of holes in successive floors and girders along a line of holes

Generation of floors and girders

Possible modification of hole-positions in a single floor/girder

Drawing of the resulting lay-out

In practical use from lay-out phase to production, we will proceed through the following steps :

- 1°) - Preparation of the lay-out according to the **above** guide-lines
  - Drawing of the lay-out
- 2°) - Automatic splitting or dividing of floors and girders when they intersect each other
- 3°) - Introduction of all the divided parts of floors and girders in the composition of a block-drawing
  - Execution of a block-drawing of double-bottom block
- 4°) - Transfer of double-bottom parts to production-phase for :
  - . production transformations
  - . production identification
  - . list of pieces, nesting and so on
  - . sketches of assembly-parts

\*  
++ \*

### III- GOING THROUGH THE STEPS - ----= ----= ----= ----= ----= ----=

We will briefly go through the steps **and** will underline which are the items to take care of and which difficulties may arise.

#### "1.1 - Preparation Of the lay-out and drawings

We must first of all, as this has not been done before, state that this starting phase has been developed together with the drawing of the lay-out by AKER/SRS (especially Mr. K.JACOJH:N from AC).

#### Generation of the tank-top

To obtain as a result the drawing of the tank-top (fig. 1) we have to generate successively by using appropriate norms :





- a) - Tank-top contour in the area of the double-bottom : on the drawing the tank-top contour is shown as an arrangement of contours projected horizontally even when the tank-top is composed of planes which are not at the same horizontal level (change of height) or if some portions of planes composing the tank-top are inclined.

The resulting contour seen horizontally can then have knuckle-points.

- b) - Traces of girders in the tank-top
- c) - Traces of floors in the tank-top
- d) - (opening contours in the tank-top)

As a general remark, this intermediate result contains information concerning the hierarchy of a crossing between floors and girders (which one is going through, which one is intercostal).

#### Generation of floors and girders

For all the floors and all the girders, which, at this point, exist only under the form of their trace in the tank-top, appropriate norms will generate :

Contour of the floors, as intersection in the transverse plane of contour of tank-top and contour of shell

Contour of the girders by the same method, but with the difference that for girders

We will obtain two contours : the actual contour,  
the projected contour in the XZ plane

Then, will be added to each floor and each girder:

the local stiffeners

the holes

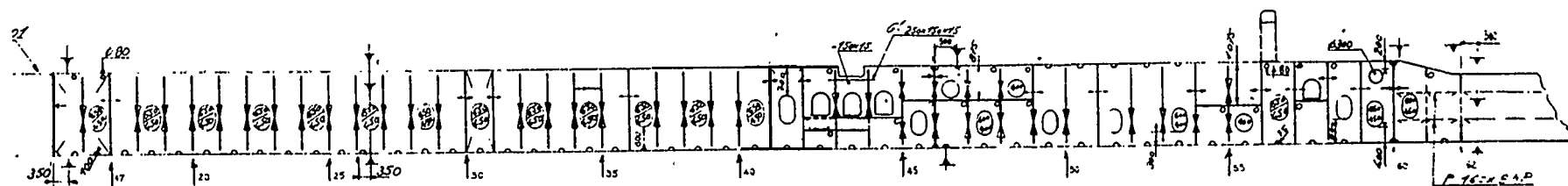
Everything is now ready to produce, after the tank-top drawing, the drawings of :

the girders in projected view (fig. 2)

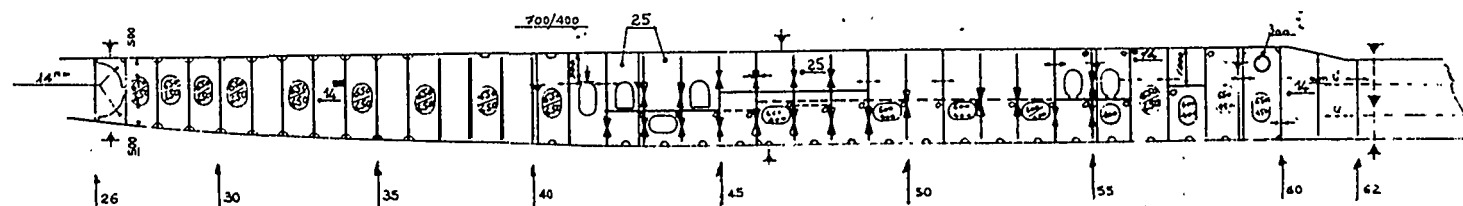
the floors at every frame (fig. 3 some floors)

These drawings, after some modifications/additions (updating of records in the database), can be used, if ready at the right time, as a very good basis for classification drawings.

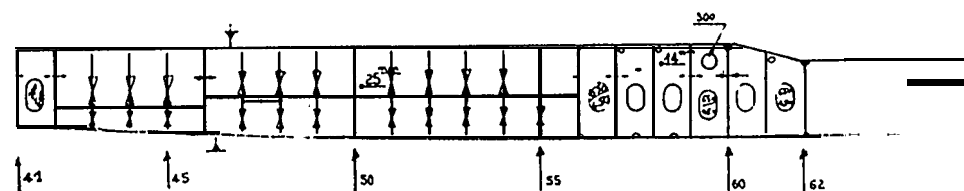
CARLINGUE CENTRALE vue de tribord



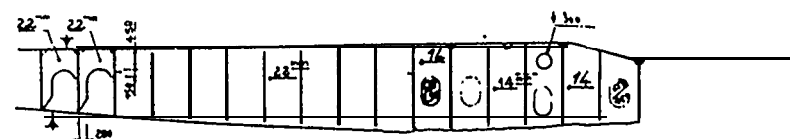
CARLINGUE N°1 vue de l'axe



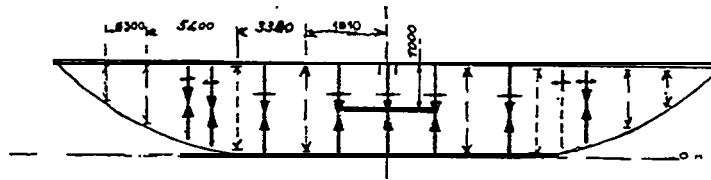
CARLINGUE N°2 vue de l'axe



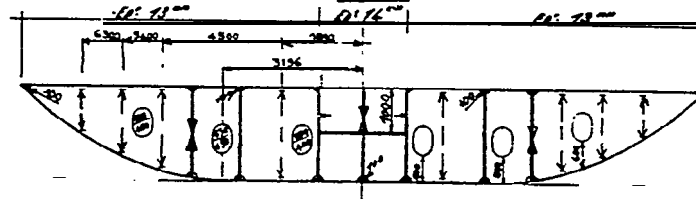
CARLINGUE N°3 BABORD vue de l'axe



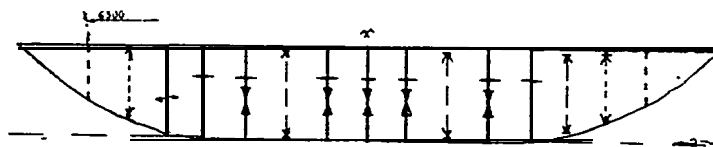
C. 57 étanche EP. 14,5 mm



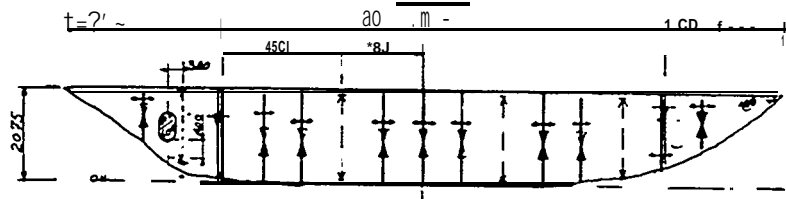
C. 58



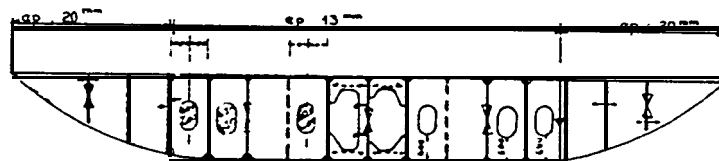
C-sg elanche 3<sub>p</sub>. 20=.



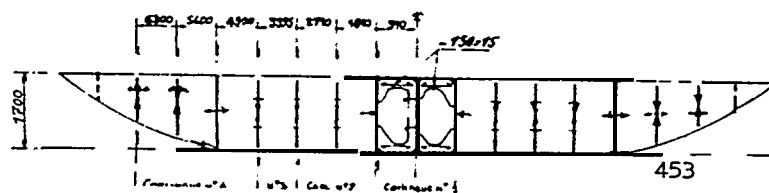
C. 60



C-61



C. 62 1 P. 44-S.



### 3.2 Automatic splitting/dividing of floors and girders when they intersect each other.

This step, for which the corresponding norms have been written at C.A., is intended for preparing the two next steps and consequently:

all parts belonging to a block must be generated separately

the same parts, most of them being already single production parts to be nested, must be ready for transfer to the production

This automatic step starts from the complete girders and complete floors and divides them at butts (in the case of girders) or between girders (in the case of intercostal floors).

It is the job of the norms to recognize each case of intersection between a girder and a floor and also to determine on each side of one element going through if the left/right part of the element divided is watertight or not.

For each girder/floor divided in several parts, there is an automatic identification system, and the list of identifications is stored (composition matrixes) so that the drawing norms will later refer only-to that list for drawing or not the part, if the part is or not included in the block.

One remark has to be made here: the standard version of double-bottom norm package generates only floor-parts with a contour between tank-top, shell and (if necessary) one or two girders, but in the case of a duct-keel for instance, close to the central girder, we have to re-generate semi-automatically (that means with a non-standard norm) the duct-keel special parts.

Another exception to the standard version is the case when an intermediate tank-top divides the floors horizontally. "This can only be solved by the afore-mentioned semi-automatic method.

The result of this step can be an intermediate drawing of no official use showing all the girders and floors divided and identified.

### 3.3 - Introduction of double-bottom divided parts in the composition of a block-drawing

#### Execution of the block-drawing

At this point, the specific way of generating a double-bottom must have produced-standard records in the database to allow the standard process of execution of block-drawings developed at C.A. '

The link has been realized by the preceding step.

Now, there will be a big composition list of everything included in the block, everything divided by the limits of the block and so on.

The computer has only administration work to perform in order to draw sequentially the whole content of the block.

When we analyse the contents of one view in the block drawing, it is composed of :

Contour of the parts which are in the projection plane of the view

Contour holes in the above parts

Traces of longitudinals penetrating the surface (or stopped on it)

Traces in the plane of the view of the parts included in other surfaces.

(for instance in a transverse view, for double-bottom we will have traces of tank-top, shell and girders)

This can be seen in some extracts of block-drawing of the said double-bottom (see fig. 4 - 5 . 6 - 7).

### 3.4 - Transfer of double-bottom parts to production

As we have seen before, the work performed for preparation of block-drawing is not far from what the production is waiting for.

We will give the list of the production transformations which have still to be executed :

Adding of cwerlength on s-me parts when necessary assembly purposes

Take care of bevel when the angle between Floor and girder or between floor-part and shell is more than a certain value

Replacing of traces of stiffeners parts by marking lines in contours

After that the production parts can be used :

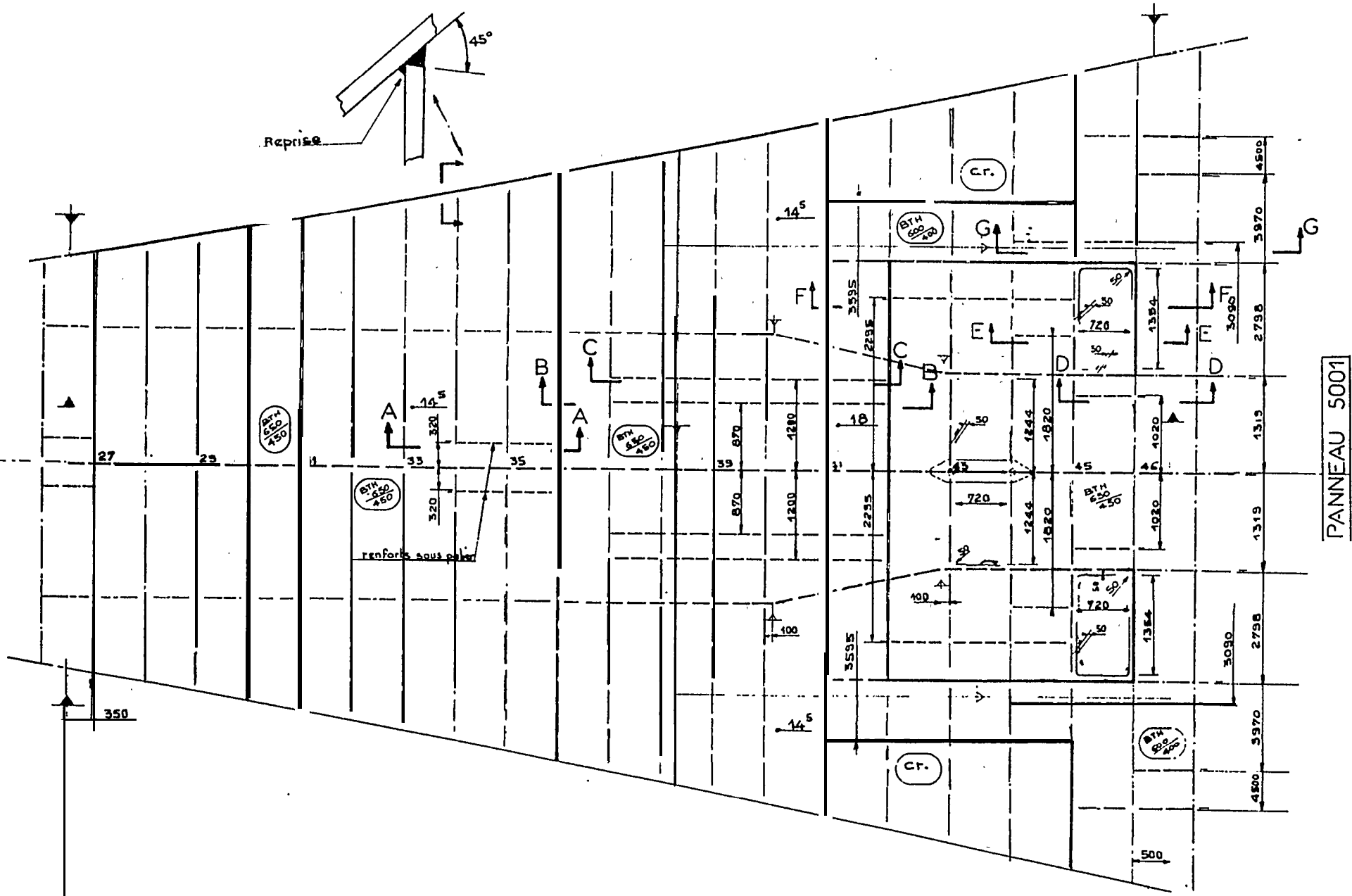
- . for nesting purposes
- . for assembly sketches
- . for lists of contents of blocks, assemblies and so on.

# PLAFOND DE BALLAST

vue de dessus

456

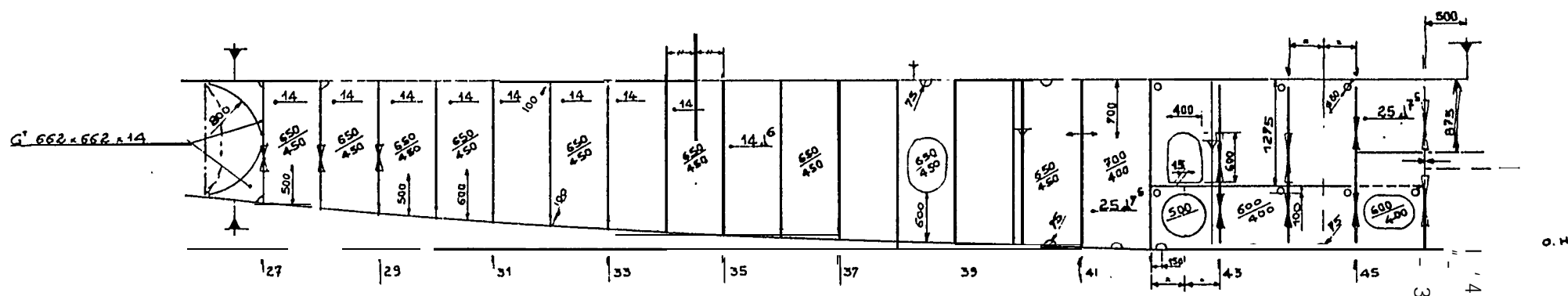
PANNEAU 5003



PANNEAU 5001

vue de l'axe

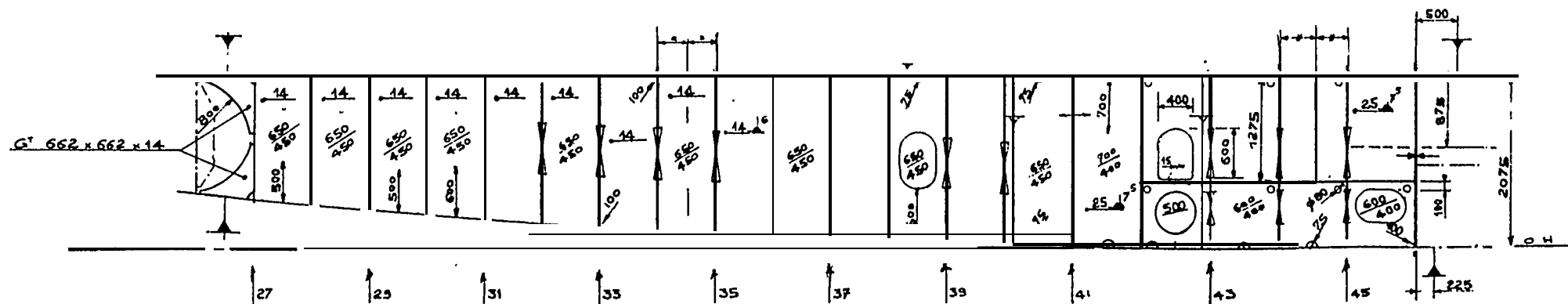
COUPE A 1810 DE L'AXE



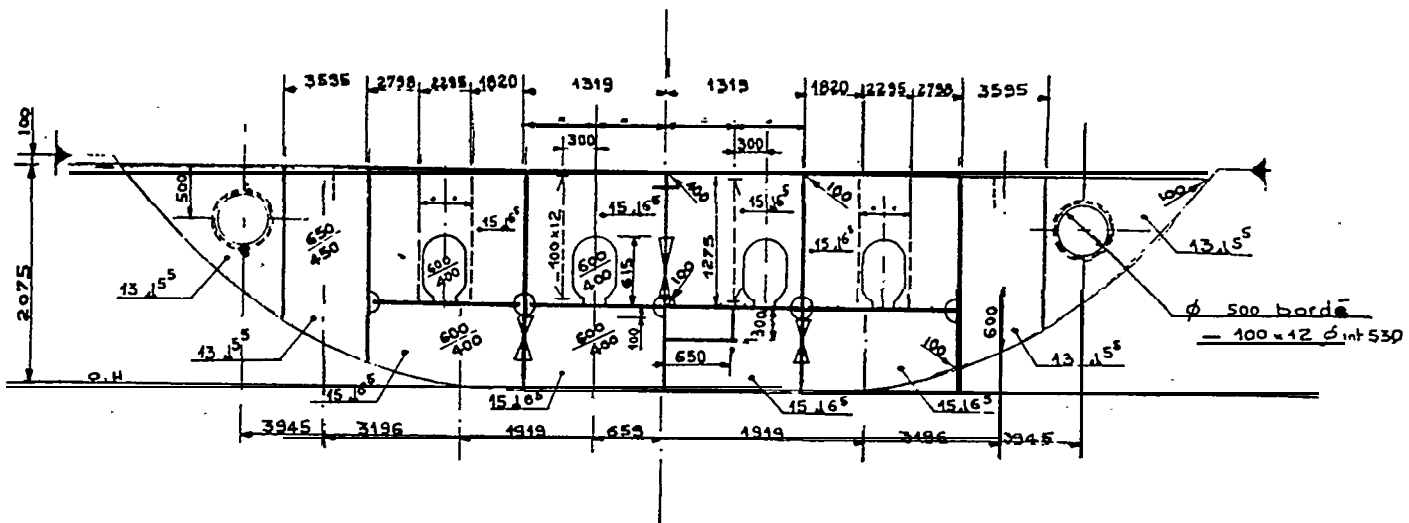
CARL NGUE      N°1      1-10 IBORD

vue de tribord

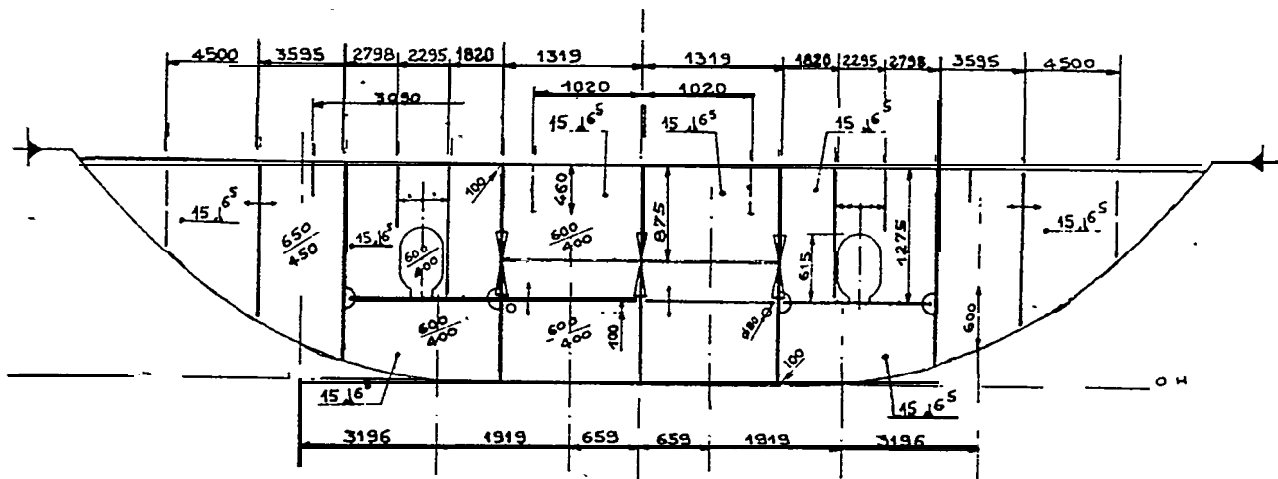
COUPE A 1810 DE L'AXE



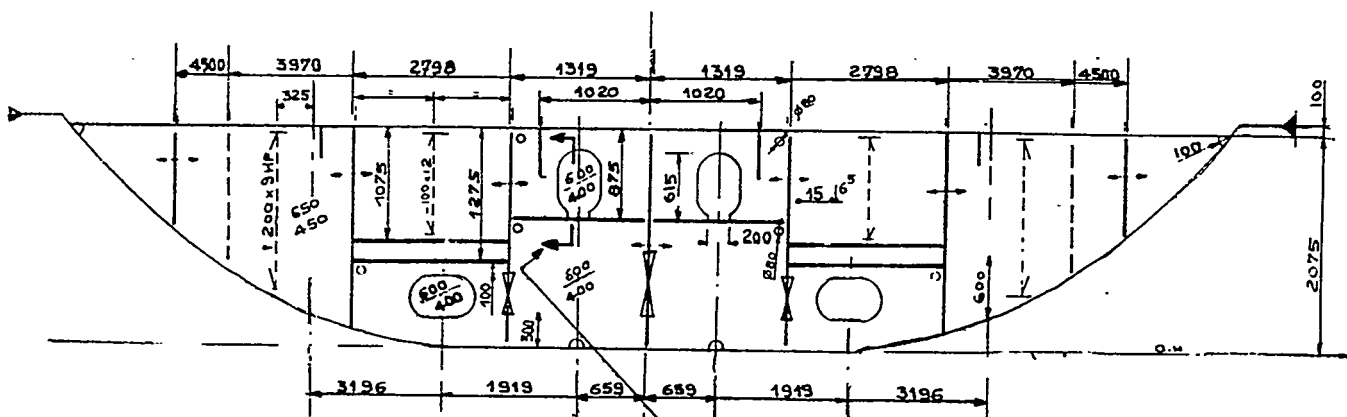
COUPLE 44    vue de l'AR



COUPLE 45    vue de l'AR

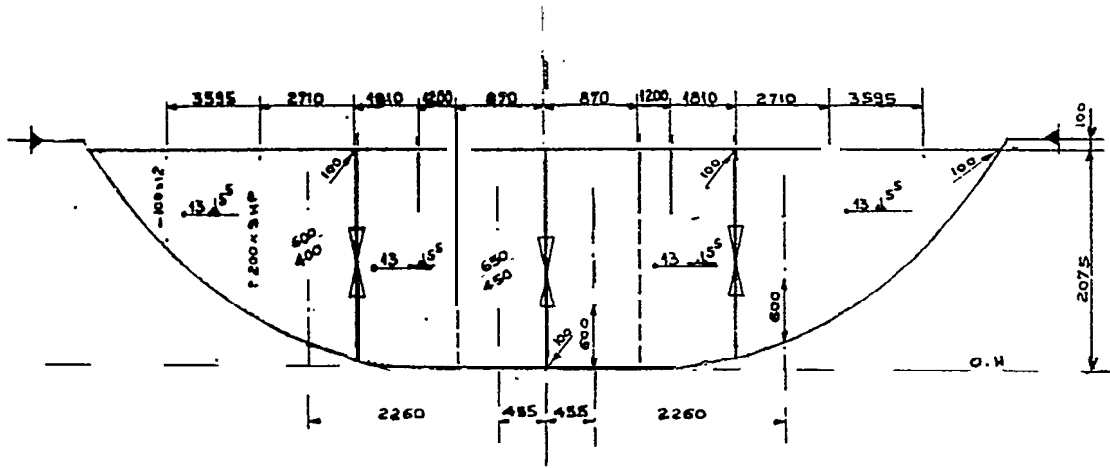
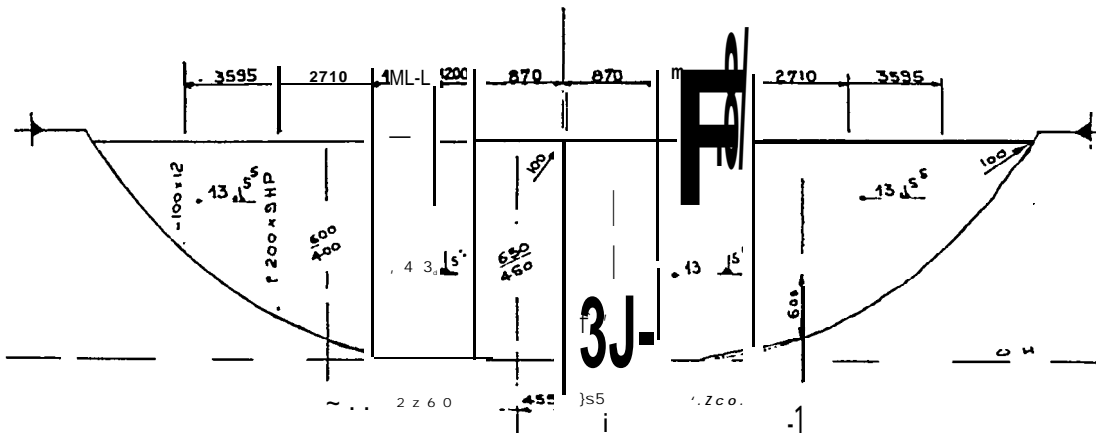
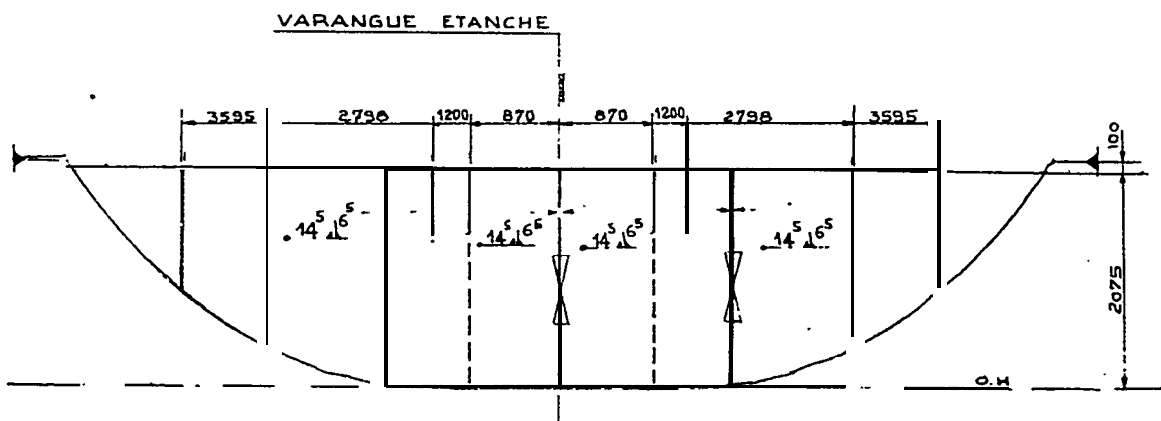


COUPLE 46    vue de l'AR



458



vue de l'ARvue de l'ARvue de l'Ar

Iv - GENERAL REMARKS AND CONCLUSION CONCERNING THE COMPLETE PROCESSING  
== == ,.,== ,== == == == == == == == == == == == == == == == == == == ==

OF A DOUBLE-BOTTOM -  
=====

It is the first time at C.A that we have run the complete process on an extensive part of the double-bottom and not only for test purposes.

The results are very promising if we have the following conditions

In the first step (for classification drawings) the man in charge of the AUIXXON design of the 'double-bottom must be very experienced with the input-preparation of norms and must be in good contact with the people in charge of designing the d.b.

Modifications of the design are a common fact when designing double-bottom, especially in engine area.

The computer and drafting equipment turn-around must ensure a good response.

The -conclusion is, that, for other parts of the ship-structure especially for ships with a double-hull the guiding principles of the double-bottom norms might be applied.

The 27<sup>th</sup> of April  
-----

J.P. BOISARD

COMPUTER GRAPHICS HARDWARE AND APPLICATION IN SHIPBUILDING

O.Eng, SRS, A/S

The general economical situation in shipbuilding and the cancelation of a number of big tankers has affected many yards in many ways. The development and application of computer technology has also been influenced. When it comes to giving priority to development projects on computer applications, the following two criteria are very important:

1. The tools should be able to handle prototype products.
2. Faster return on investment in computer technology.

As to the first point, we do believe that the system we already have is a good starting point. By adding more editing and output functions, we believe that our system will be better suited to handle

.

As to the second point, we think it is right to use the same economical criteria for investments in computer technology as we use when investing in any production equipment or technology.

Even if life should be easier for the shipbuilding industry, it is not likely that investments in computer technology will be handled in the same way as 10 - 15 years ago. Most yards will not be allowed to invest in more than they can utilize and make profit from within a short period of time.

Those of us who are used to the "good old days" will probably react with certain views on how the development of computer assisted systems will progress under such conditions. What about the realization of all the good ideas we have? If we do not get the setup of computer hardware and software we had in mind, we do not see how our philosophy can be implemented. This is of course a problem, but there is a solution to it. Think the situation over once more, but now within the technical and economical framework of today. There is usually another approach, and maybe even a better one.

r  
~ In cooperation with CIIR, the Aker group and SRS has worked on these problems for about one and a half years. The aim of the effort. is partly to develop operational application programs, but also to establish a knowledge about the possibilities of using low cost graphical terminals in our applications. The most significant results from this project are listed below.

An operational interactive parts nesting program.

Subroutine packages for handling of input commands, database administration, error messages, communication with graphic displays etc.

A concept and systems design for future development of such systems.

A specification of a general tool for editing and presentation, Of drawings from databases containing geometry elements.

know-how about the computer graphics technology and available hardware and software.

The last point is of particular interest when it comes to investments and economical aspects. Computer graphics techniques are traditionally based on special and rather expensive equipment. However, when investigating the problem a bit closer and in the light of the needs the shipbuilding industry has, we have found that a yard may have access to this new technology for a reasonable amount of money.

Computer graphics is very important, but not always central.

Graphical functions are natural parts of systems like Autokon and Auto-fit. We often think of computer graphics as output functions like scaling, making projections, hidden line removal etc. However, a graphics system has also several input functions which in certain applications may be very useful (digitizing, additional graphical info via menu printing via display screen etc. ).

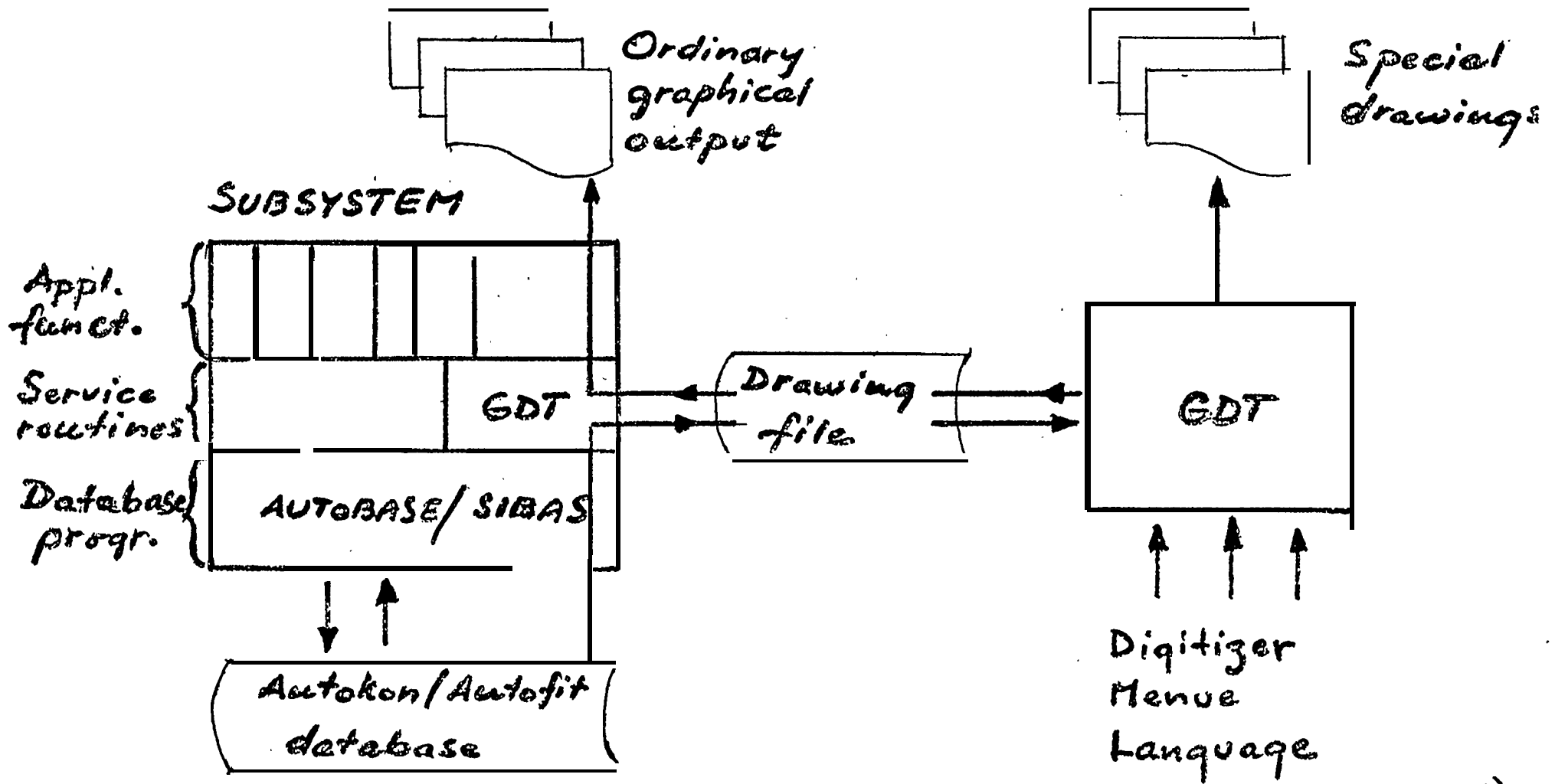
The "graphical" function in relation to Autokon and Autofit may be split in two categories (see fig. 1):

1. Direct output in connection with the execution of the application programs.
2. Editing and presentation of final drawings (documents).

The type 1 output is typical for the Autokon programs we know today. The output is initiated by some application function and the purpose of the output, is to serve as documentation of the information that resides in the database after the execution of the program. An example of such output is the part drawings from ALKON. Other output, like the bodyplan drawing from FAIR and the LANSK1 drawing acts both as a base for the database and a base for a physical drawing. The third type of output is represented by the drawings from SHELL and NEST, which primarily are a control of the contents of the cutting tapes, but serve also as a base for the production drawings prepared for the operator of the cutting machine. In general, this output is rather rigid as to content and layout. The necessary additions and modifications for getting a final drawing will have to be done by traditional manual means.

The type 2 output is what we will be able to produce when the GDT (General Drafting Tool) is operational. As shown in fig. 1, this drafting function will be implemented as a freestanding system. Some characteristic data is given in fig. 2. The idea behind the system is to give the designer/draftsman the possibility of making the drawings completely finished by means of a computer graphics system. In addition he will have the drawings and the information on them organized in a database, which we may call a "computer assisted library of drawings".

The GDT will serve as a general tool for all applications that require editing of predefined information to produce final drawings. Such a function is very general, because the system does not have to have any "knowledge" of what the graphics, symbols and text represent



Implicit and explicit implementation  
of GDT (General Drafting Tool)

FIG 1

## PREPARATION OF OUTPUT

START, RESTART, END  
INCLUDE, EXCLUDE  
TEXT  
KILL  
POS, ROT, MIRR  
SCALE  
FORMAT  
:  
etc.

FIG 2

## PRESENTATION OF OUTPUT

PRESENT  
SHOW  
FETCH  
DELETE  
SPLIT  
SELECT  
CHARDIM  
:  
etc.

GDT - Examples of functions

Such knowledge is supposed to be found partly in the application database, but also in the brain of the designer/draftsman. The idea is, therefore, that GDT shall be used with Autokon and Autofit, both as a freestanding system and in connection with direct output from application programs.

#### Computer graphics as "turnkey system" or "do it yourself kit"?

In our investigation a number of alternatives were listed and removed from the list again, because they were too expensive or they were not supported in Norway.

In the last phase of The investigation, we had two principal alternatives left:

1. Turnkey system
2. Build our own system from standard components.

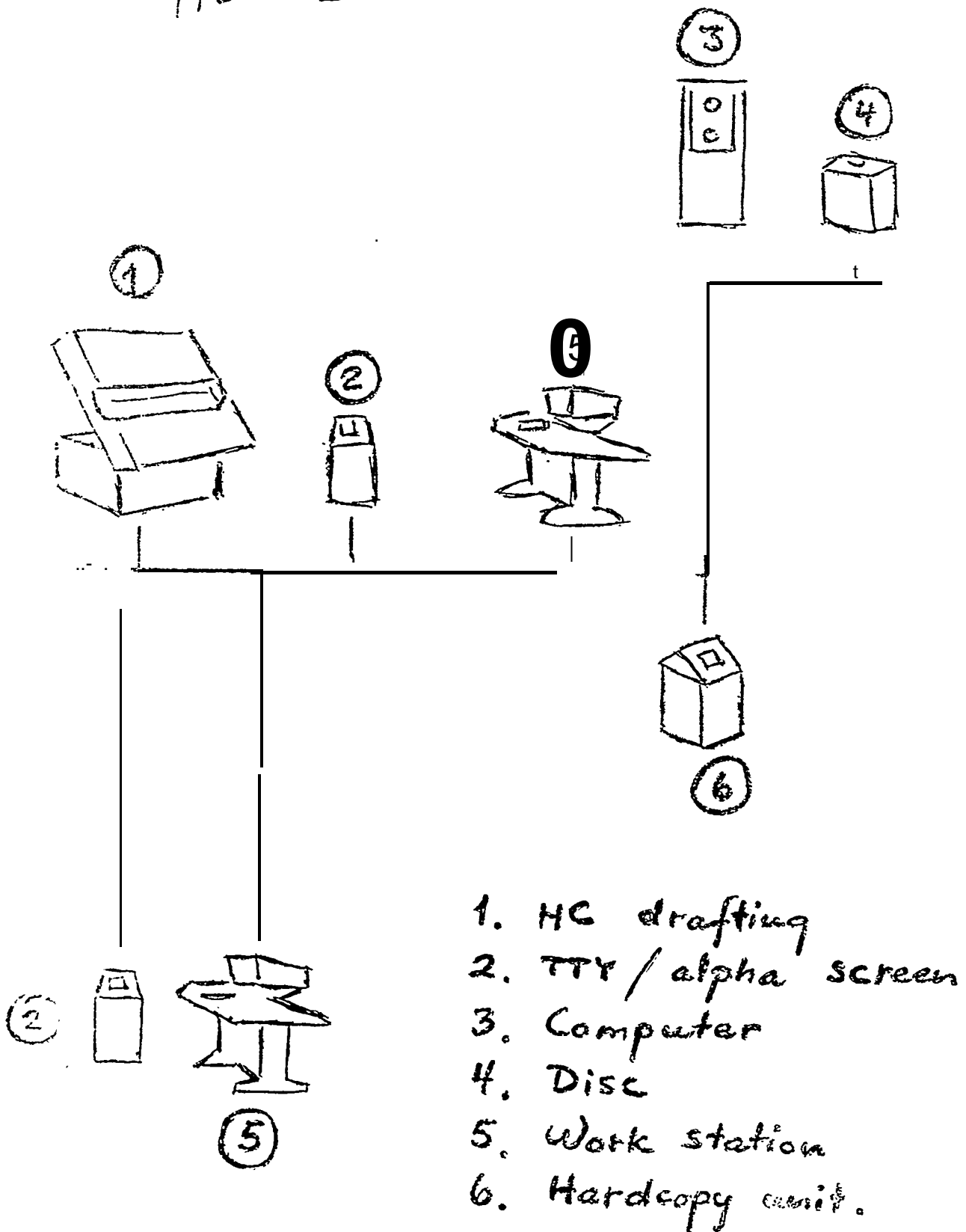
The final conclusion was to go for alternative 2 as the main rule, but to buy turnkey systems when that would be the most economical solution to a special graphics problem.

The general characteristics of such a turnkey system are given below. See also general hardware setup in fig. 3.

- . Price ranges from \$200.000 to \$300.000, dependant on the number of work stations and make.
- . Typical functions are:
  - . 3D geometry input from language, menu and coordinate readout device.
  - . Possible to define standard symbols for more effective preparation of drawings.
  - . A database for administration of the "drawing file".



FIG 3



TYPICAL TURNKEY SYSTEM

possible to get new projections on the basis of the drawings in tune database.

Hardware components

- . A number of work stations comprising a graphical screen (storage), keyboard and a menu facility.
- . Drafting table
- . Digitizer
- . Computer
- . Disc station.

The general impression is that these systems are powerful and advanced drafting tools. There is a good integration between the miscellaneous hardware and software components. This makes a good system for general drafting, but makes it less suited for integration with other applications. The system is very general, and quite a bit of effort will have to be put into it before you have an efficient application tool.

As you will see from the point above, a turnkey system is an interesting drafting tool. How interesting is, however, very dependant on the yard's specific needs, its present tools or methods, its philosophy for further development and the economical situation.

After serious considerations, the Aker Group decided not to go for a turnkey solution. However, computer graphics techniques and equipment for development and use of applications based on this technology has a high priority. The development philosophy will be to build up the hardware configuration of relatively standard components. The system design and the software components will be made fairly general, so that changes in the hardware setup may be easily carried out.

The general setup of hardware is shown in fig. 4. The systems we develop will in most cases be made available both on the central computer and locally. The hardware situation will be different from one yard to another, and the volume of the application will vary quite a bit.

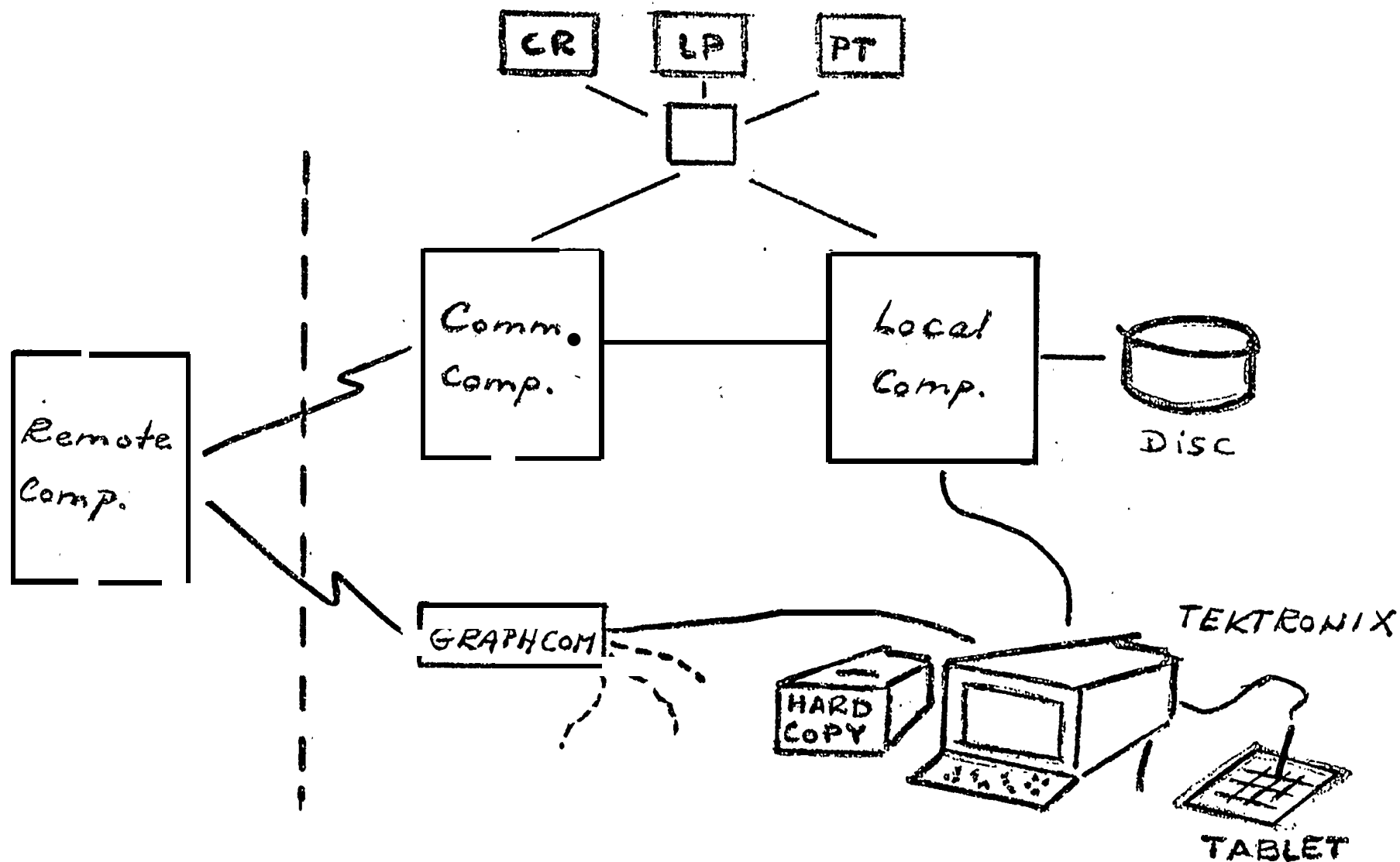
When there is a need for a big computer to solve the application problem or when the application volume is fairly low, the alternative with direct access to a central computer is very interesting. If the volume is very low, an ordinary 300 - 600 baud connection will be sufficient. However, most applications will benefit from a higher transmission speed. If a GRAPHCOF.1 adapter is inserted on the line, the speed may be increased to 9600 baud. The same adapter may be used as a line concentrator for up to 4 terminals simultaneously. In addition, hardcopy units may be added. Normally one unit may be shared between a number of terminals (maximum 1). If then the terminals are equipped with a 'tablet', input may be given via menus, and the resulting setup will be a rather efficient tool. The price for this will depend on which level is chosen. Approximate component prices are (in Norway):

TEKTRONIX 4014 display	<b>\$13.000</b>
TEKTRONIX hardcopy unit	\$6.000
GRAPHCOM adapter	\$9.000
TEKTRONIX tablet	\$6.000

From a user's point of view, the alternative with a local computer is very similar to the remote computer alternative. What differences he will see will probably vary with the type of computer and the application.

The implementation of such a system will be rather different from one yard to another. The implementation sequence and the dimensioning of the equipment (number of terminals, disc # capacity etc) will depend on what equipment the yard has available > the application to be supported, the volume of the application.

470



HARDWARE SETUP

FIG 4

### Drvelcn.xnent plans

So far, two systems are operational:

1. Interactive parts nesting program, which is implemented on a local computer. Its input is based on part descriptions made by ALKON, and stored in a Autokon database. The parts are produced on the remote computer and transferred to the local. computer via telephone line and a communication computer.
2. On-line preparation of isometric pipe drawings. This system is implem.entcd on a remote computer, and is operated from a TEKTRONIX 4014 display via a telephone line. We do not have a GRAPHCON adapter yet, snd the transmission speed is 300 baud.

These two developments are right now in a final testing stage in the design offices, and will be in full operation within this year.

The next development will continue on the line we have started. Within this year three projects will be started:

1. On-line parts coding and editing. This will be a set of coding and editing commands to support the parts nesting function we already have. The idea is to do the main bulk of the parts generation by means of ALKON on. the big computer and transfer these to the local cor.puter for modification, if needed, and finally nesting.
2. The General Drafting Tool (GDT) will be implemented as a free-standing system with necessary functions for editing and presentation of drawings. It will be based on predefined geometry from one Autokon database. In this version of the system, only 212 functions will be implemented.
3. The third project with a graphics approach, will be the Autofit subsystem fcr preparation of functional models and diagrams for piping systems (P&I diagrams). This is an

example of an application where the graphics part of the system will be rather peripheral to the application, but anyway important as a bridge between the application database and the user.

In addition we will continue our work with simple utilization of the display terminal as fast "drafting machine" for output from our present programs.

### Conclusions

Today's technology will help the shipbuilder in adding a new dimension to the present CAD systems. Computer graphics implies on-line access to the computer system, and will give the users a more direct contact with the computer assisted design process. Fast information retrieval and graphical presentation of the contents of the database will make the database more user oriented than today.

The computer graphics technology is now developed far enough to be applicable in CAD systems for use in the shipbuilding industry. It is however a long way before we see the end of this development, and our present systems should be made flexible enough to be able to absorb elements from the further development.

INTERACTIVE GRAPHICS

Mr. Maisson

Use and future applications of graphics display units within IHC - Holland.

Introduction

The IHC data processing R & D group is a "centralized group with responsibilities in the fields of:

- development of new software
- software support and evaluation
- hardware support

About one year ago, a Tektronix 4014-1 graphics display unit was installed to investigate the possibilities of interactive graphics.

In this paper we will shortly describe the experiences gathered with this terminal, as well as our plans for future use and implementation.

Problems of present systems

Most of the software packages we are using today are batch oriented. Working with these software packages however does affect the users' motivation after some time. Users' complaints in general are:

preparation of input forms is an annoying job.

the user has no possibilities of controlling the process after delivery of his input forms.

there is a pretty big change the user has to solve a problem twice; the first time when he is preparing his input and the second time when he has to correct his errors.

turn around times are always too long.

In short we may say that the present software is computer oriented and not user oriented.

The answers to the problems mentioned above are in our opinion:

- direct interactive contact between user and computer
- more and faster visualization of numeric data

As hardware costs are decreasing and manpower costs are still rising, we have to prepare for an optimal use of a technicians capabilities, considering the computer just as a tool.

## Main starting points

As the basic function of the Tektronix is graphic representation of numerically processed information, we decided that the graphic display unit should be able to function as an integral part of our existing drafting and plotting equipment.

Any drawing that can be done on a drafting machine or a plotter should be able to be done on a graphics display unit as well. So our first step was to develop the appropriate software.

Looking backwards we are still very happy within this decision. It extended the applicability of the graphics display unit beyond the typical field of interactive design into the area of fast verification of numerical information which is processed by batch oriented systems like Prelikon, Autokon and stress analysis programs.

## Terminal characteristics and software

The Tektronix 4014-1 is a storage tube graphics display unit with a cross-hair pointing device and an ASCII keyboard. It is connected to a UNIVAC 1106 via a 600 baud line.

Important extra features are:

- hard copy unit
- data tablet

As the hard copy unit speaks for itself, we are especially interested in the use of the data tablet. We are now going to test it for its possibilities.

The software is developed by the R & D group with a mixture of Tektronix standard software and typical IHC routines.

Main problems which we experienced up to now were:

screen accuracy too low

The relatively low number of points on the screen affects both the accuracy of detailed drafting as well as the use of the cross-hair cursor for coordinate input. The first problem has now been solved via a "Zooming" method and we hope to solve the coordinate accuracy in the same way.

partial rub out possibilities do not exist

This problem is caused by the storage tube characteristics. The only way to alter a part of a drawing is: give new input, clear the screen, reprocess and make a complete new drawing. We hope to solve this problem by adding a hardware "buffer" and the use of adapted software.

For our main applications, these problems are not too critical.



## Applications\_

At this moment the Tektronix is used in three applications areas. These are:

- fast graphic verification of
  - Prelikon output
  - Autokon output
  - Stress analysis
  - input and output
- Design of
  - piping systems
  - developable hullforms**
- Graphics of static, administrative and financial information.

In this presentation we will shortly discuss the first two applications.

### 1. Verification

At the moment many pictures are generated by Prelikon, Autokon, stress analysis programs etc. The increasing number of pictures has to be drawn by a numerically controlled drafting table. The operator of the drafting table does not know the pictures, so he does not know the starting point of the drafting sequence etc. Results: long lead times, mistakes, user frustration.

Using the Tektronix the user is able to see the sequence and the big errors he has made without waiting.

The R & D group has made a program to read ESSi elements and draw these on the display. Almost all of the auxiliary functions are recognized by the program and a special circle routine is developed for this purpose. Some applications are:

- drawing the points generated by Alkon.
- drawing of frames generated by stress analysis programs
- drawing plates from the Nest and Shell programs
- drawing the output from Fair

To be able to see more detailed information it is possible to enlarge a part of the picture in a very easy way.

Tests showed that the use of a graphic display unit gives a dramatic productivity improvement in norms programming.

## 2. Design

A very promising application is interactive design of piping schemes. The user does not have to draw the same symbols every time again, all measurement, numbering and counting of fittings and accessories is performed by the computer. Results of the program are:

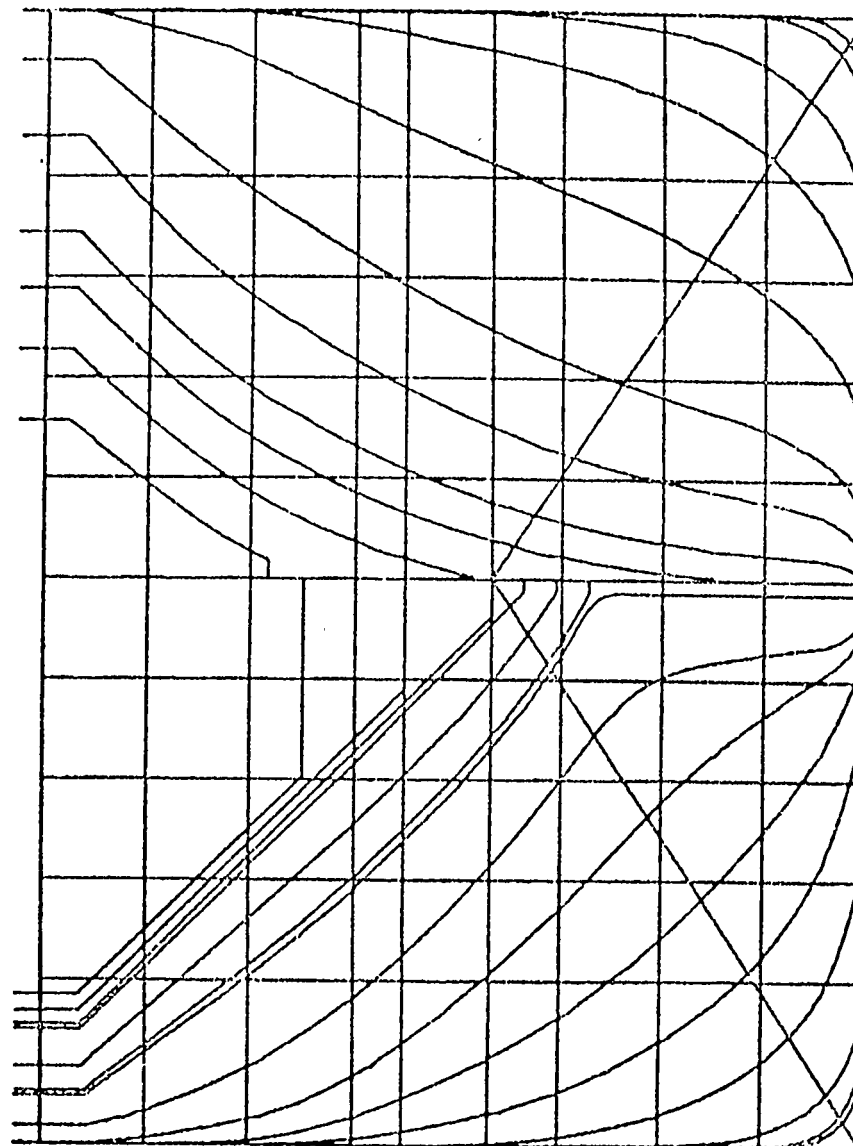
- Hard copy of piping scheme's
- Bill of materials listing
- Shop floor information

Our final conclusion is that, though there are some negative points, the graphics display unit is a very useful tool and has a large application area.

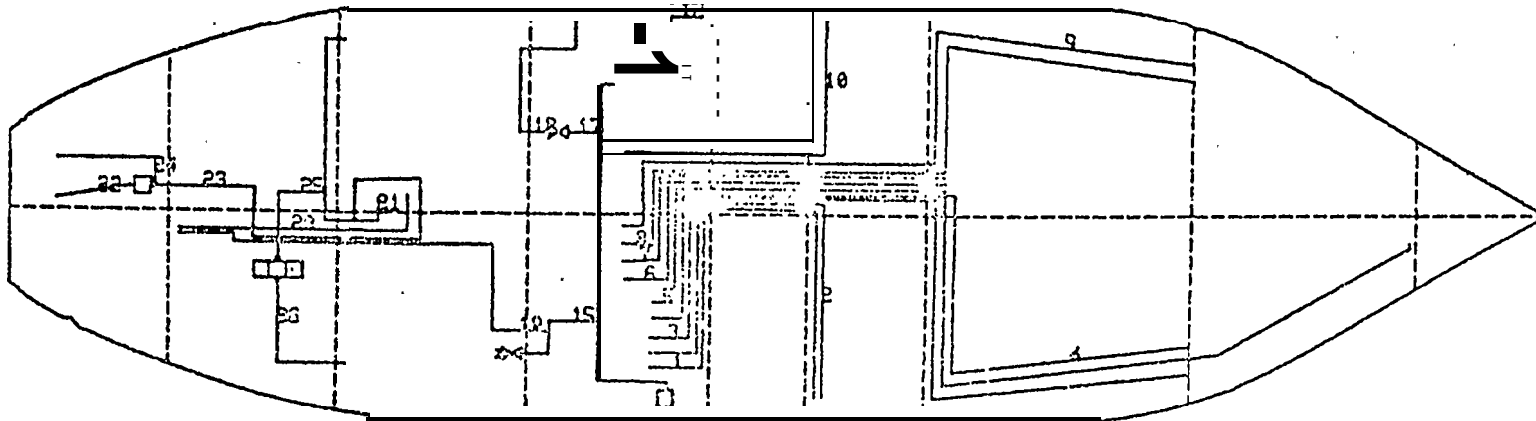
### Future plans

1. Next year we are going to install Tektronix displays for use in norms and parts verification in three yards.
2. Further research of the applicability of the data tablet for fast input generation in structural analysis programs.
3. Application of graphics in interactive nesting.  
Research of application of graphics via minicomputers.

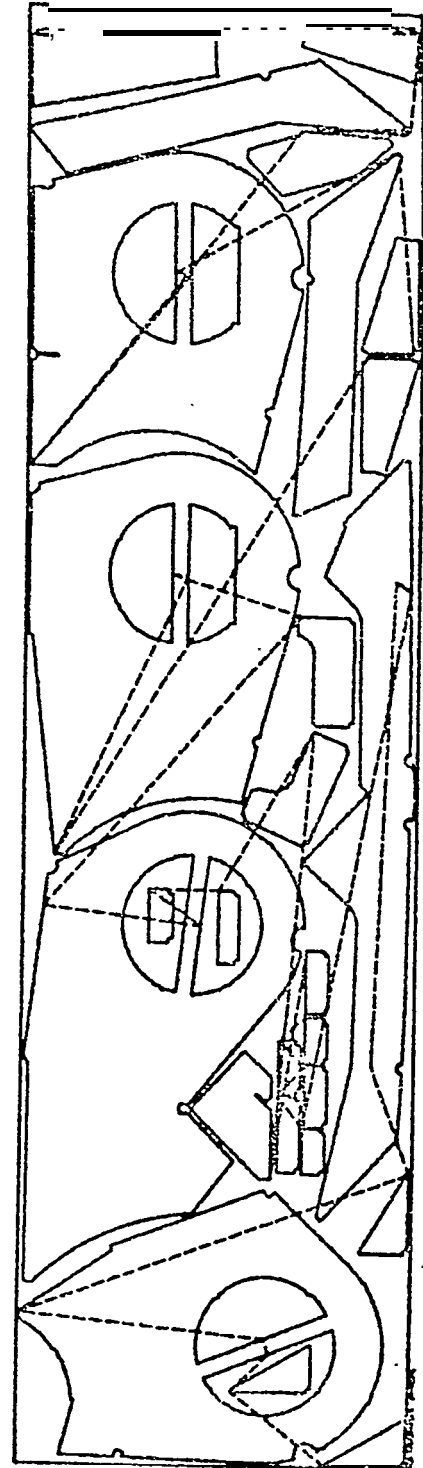
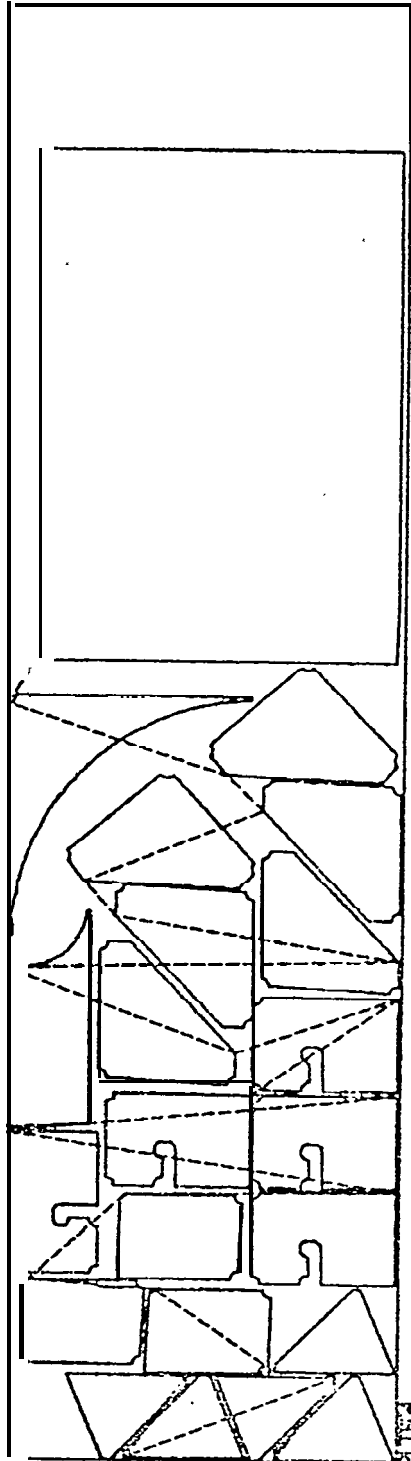
PRELIKON

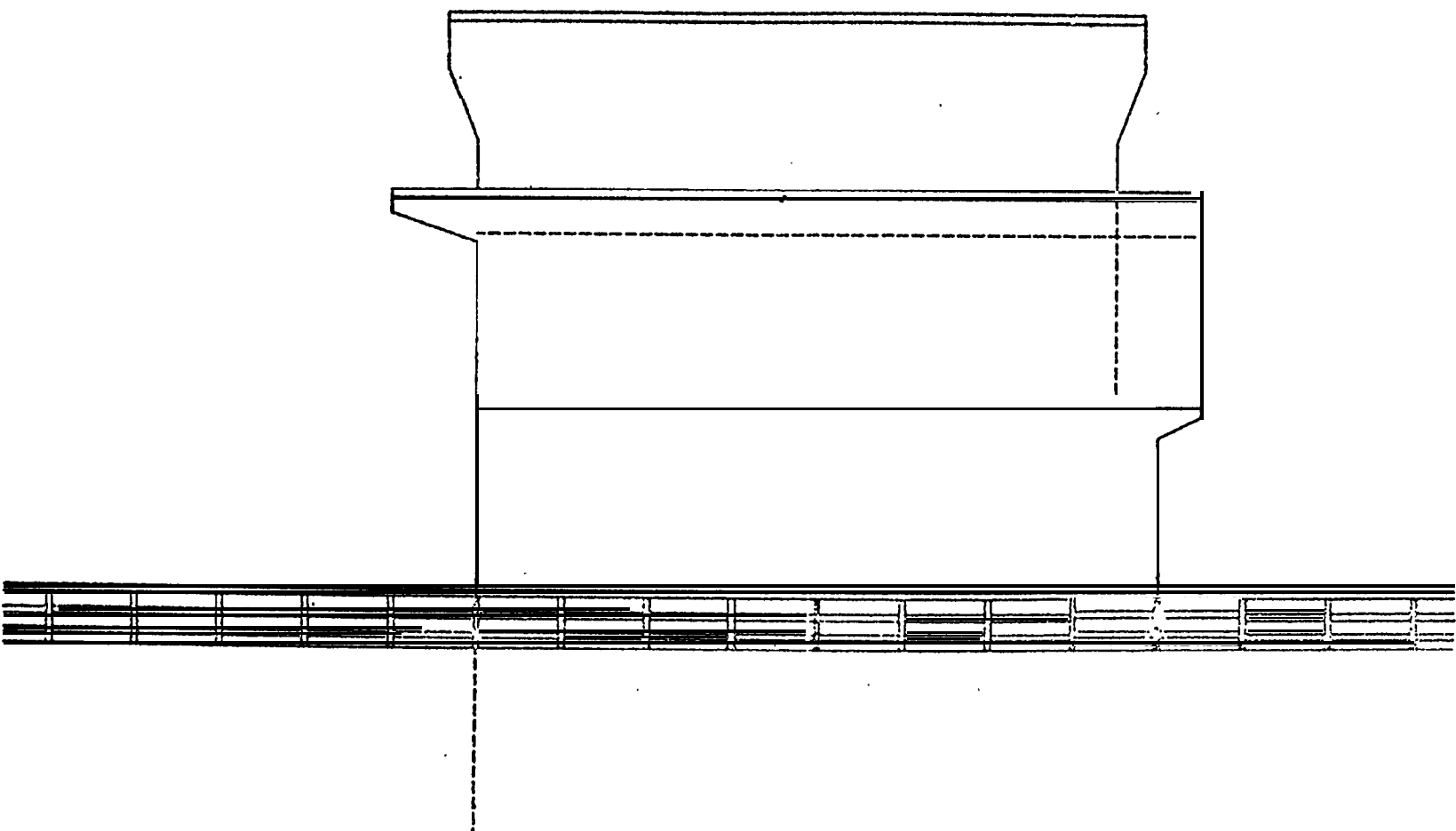


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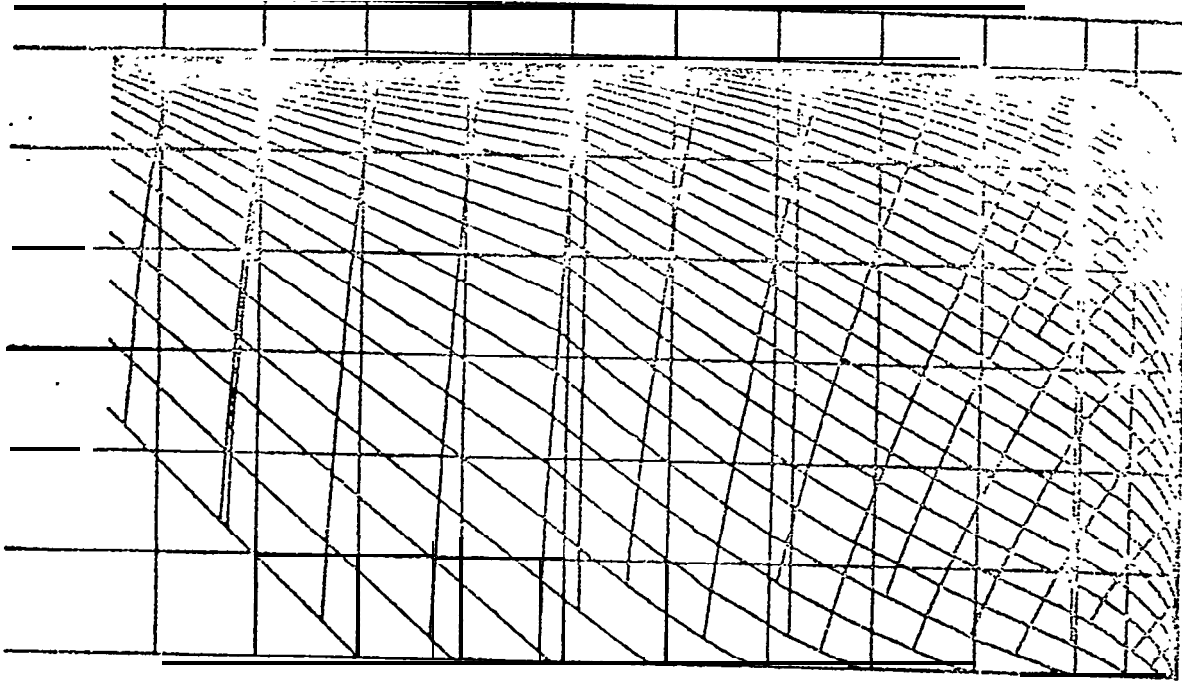


AUTOKON NEST

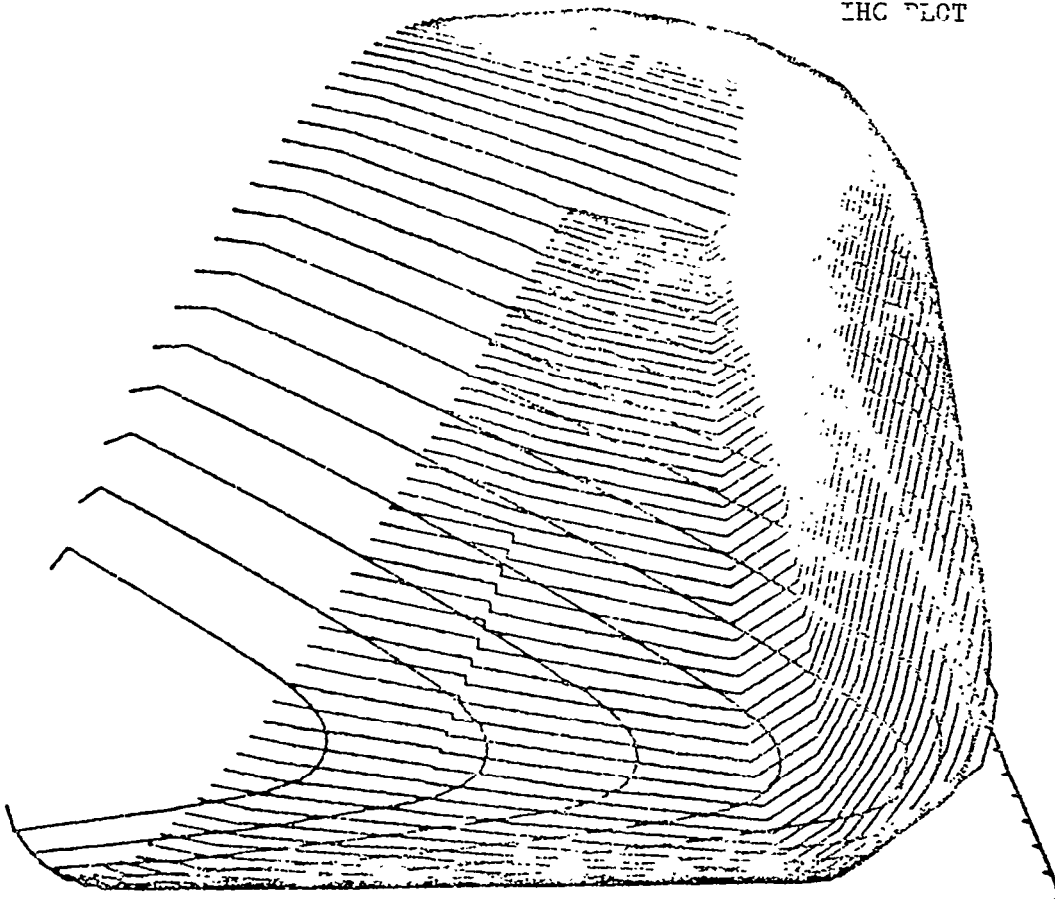




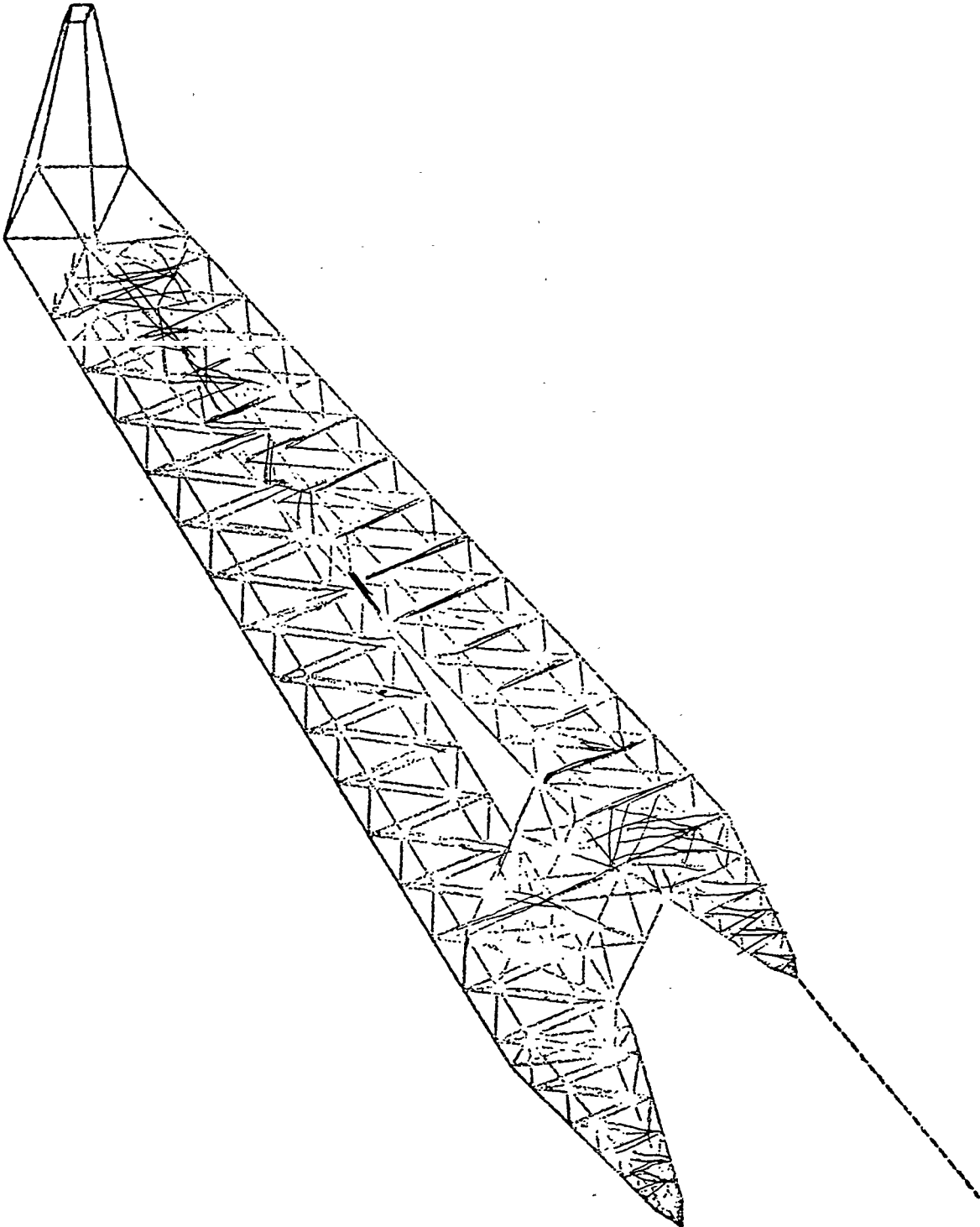
AUTOKON  
LANSKI



IHC PLOT

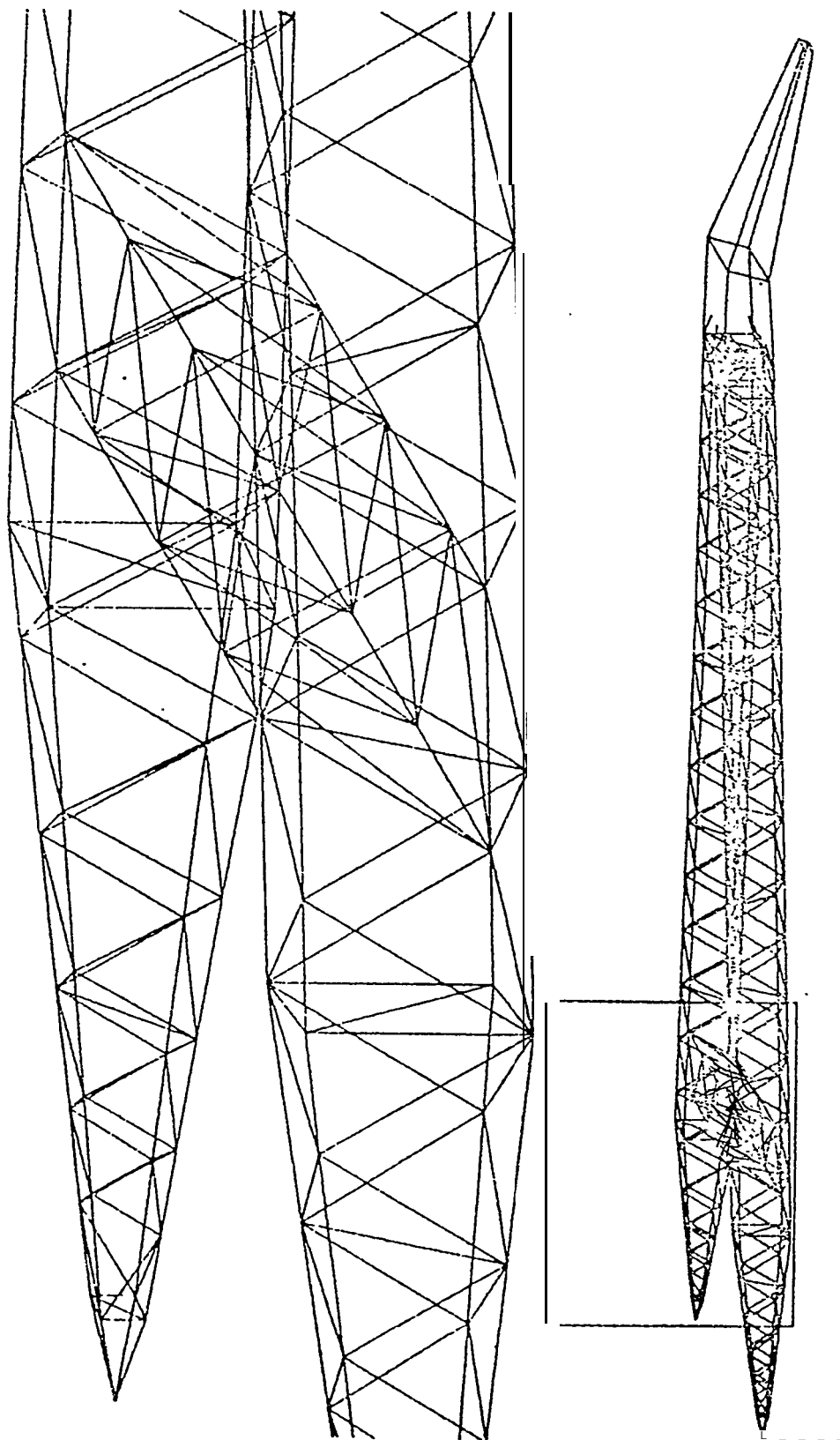


STRESS ANALYSES





## STRESS ANALYSES



## APPENDIX A

### AGENDA

## TUESDAY, JUNE 15

8:00  
-5:00 REGISTRATION BLUE COAST LOUNGE

8:45 GENERAL SESSION BALLROOM, WEST

WELCOME  
J. J. Garvey, Maritime Administration,  
U. S. Department of Commerce

ROLE OF THE SHIP PRODUCTION COMMITTEE  
IN PRODUCTIVITY IMPROVEMENT  
E. L. Peterson, Peterson Builders, Inc.

THE POTENTIAL OF COMPUTER-AIDED  
MANUFACTURING FOR INCREASING  
PRODUCTIVITY IN AMERICAN SHIPBUILDING  
J. M. Evans, National Bureau of Standards

10:15 INFORMAL DISCUSSION PERIOD

10:45 GENERAL SESSION BALLROOM, WEST

THE V/W REAPS PROGRAM FOR U. S.  
SHIPBUILDERS  
J. C. Williams, IIT Research Institute

A STATUS REPORT: THE REAPS AUTOKON  
SYSTEM  
P. D. Taska, IIT Research Institute

A SURVEY OF SHIPYARD WORKER ATTITUDES  
G. A. Muench, San Jose State University

12:15 LUNCH

1:45 GENERAL SESSION BALLROOM, WEST

AUTOMATION OF DESIGN AND MANUFACTURING  
THROUGH GROUP TECHNOLOGY  
J. Tulkoff, Lockheed-Georgia Co.

CODING AND CLASSIFICATION AS AN  
INTRODUCTION TO GROUP TECHNOLOGY  
R. F. Guise, Manufacturing Data Systems, Inc.

2:45 INFORMAL DISCUSSION PERIOD

3:15 GENERAL SESSION BALLROOM, WEST

SPARDIS — A SHIPYARD PRODUCTION  
CONTROL SYSTEM  
J. McQuaide and C. S. Jonson, National Steel and  
Shipbuilding Co.

SPADES SYSTEM CURRENT DEVELOPMENTS  
A. Schulze, Cali and Associates

1:30  
-5:30 RECEPTION  
Sponsored by

CODE GA ROOM

8:00 GENERAL SESSION BALLROOM, WEST

THE AUTOKON APPROACH TO INTERACTIVE  
TESTING  
J. Oelan, Shipping Research Services A/S

THE ADAGE NESTING AND DRAWING SYSTEM  
N. Shattuck, Adage Inc.

SPADES INTERACTIVE GRAPHICS AT AVONDALE  
SHIPYARD  
F. Cali, Cali and Associates

SUPERNEST — AN AUTOMATIC NESTING  
PROGRAM  
G. J. Jamiel, International Harvester Co.

## WEDNESDAY, JUNE 16

8:00  
-4:00 REGISTRATION BLUE COAST LOUNGE

8:45 GENERAL SESSION BALLROOM, WEST

IMPLEMENTING THE U. S. NAVY'S HULL  
DEFINITION PROGRAM IN U. S. SHIPYARDS  
J. C. Gebhardt, CADCOM, Incorporated

EXPERIENCE AND PROSPECTS WITH THE  
CASDAC HULL SUBSYSTEM  
D. W. Billingsley, Naval Ship Engineering Center

BIVARIATE SPLINE FAIRING  
P. RAWAT, Hydronautics, Inc.

EXPERIENCE WITH FAIRING AT NEWPORT NEWS  
Dry Dock Co.  
R. C. Moore, Newport News Shipbuilding and  
Dry Dock Co.

10:45 INFORMAL DISCUSSION PERIOD

11:15 GENERAL SESSION BALLROOM, WEST

AUTOKON AT A SMALL SHIPYARD  
J. Harkcy, Port Weller Dry Docks

THE NASA TECHNOLOGY DISSEMINATION  
PROGRAM  
N. Logavero, NASA Headquarters

12:15 LUNCH

1:45 PARALLEL SESSIONS

SESSION 1 BALLROOM, WEST

SHIPYARD APPLICATIONS OF THE  
MITSUBISHI HORIZONTAL FILLET WELDING  
ROBOT

A. Kamata, Mitsubishi Heavy Industries, Ltd.

AN AUTOMATIC HULL SUBASSEMBLY  
MACHINE AND A CENTRALLY-CONTROLLED  
PIPE PROCESSING SYSTEM  
A. Kamata, Mitsubishi Heavy Industries, Ltd.

SESSION 2 MADRID ROOM

USE OF PRELIKON AT ZIGLER SHIPYARD  
S. Mohammad, Zigler Shipyards, Inc.

THE NAVY COMPUTER-AIDED DESIGN AND  
CONSTRUCTION CABLING AND WIRING  
PROGRAM  
J. Mellis, Naval Ship Engineering Center

3:00 INFORMAL DISCUSSION PERIOD

3:30 PARALLEL SESSIONS

SESSION 1 BALLROOM, WEST

THE NEWPORT NEWS APPROACH TO N/C  
WORK IN PRODUCTION  
K. W. Pleasant, Newport News Shipbuilding  
and Dry Dock Co.

NASSCO ORGANIZATION FOR THE SPADES  
SYSTEM  
G. Uberti and J. Wasserboehr, National Steel  
and Shipbuilding Co.

ORGANIZING FOR N/C PRODUCTION  
V. H. Nuzzo, Avondale Shipyards, Inc.

SESSION 2 MADRID ROOM

AUTOKON IN PLAN PRODUCTION  
A. P. Wickham and R. Kucharski, General  
Dynamics Quincy Shipbuilding Div.

A REPORT ON THE 1976 AUTOKON USERS  
CLUB MEETING  
H. Saetersdal, Shipping Research Services, Inc.

5:00 ADJOURNMENT

APPENDIX B

ATTENDANCE LIST

ATTENDANCE LIST  
REAPS TECHNICAL SYMPOSIUM  
Riviera Hyatt House  
Atlanta, Georgia  
JUNE 15-16, 1976

ADAGE INC.  
1079 Commonwealth Ave.  
Boston, Massachusetts 02215

Ned Shattuck  
International Sales Manager

AMERICAN SHIPBUILDING COMPANY  
400 Colorado Ave.  
Lorain, Ohio 44052

Ray Francis  
Technical Manager

AVONDALE SHIPYARDS, INC.  
P. O. Box 50280  
New Orleans, Louisiana 70150

John H. Leary  
Manager, Computer Applications  
Vincent H. Nuzzo  
Assistant Supt., N/C Mold Loft  
Bob Rourci au  
N/C Foreman  
Lester Vicknair

BATH IRON WORKS  
700 Washington Street  
Bath, Maine 04530

D. Austin  
Mold Loft Foreman  
S. Endris  
Hull Drafting Supvr.  
C. French  
Project Engineer

BETHLEHEM STEEL CORPORATION  
Sparrows Point Shipyard  
Sparrows Point, Maryland 21219

Vernon G. Adams  
Designer

Douglas Flett  
N.C. Program Superv.

Bruce G. Bohl  
Engineering Program Analyst

Edward F. Sweeney  
Chief, Computer Applications

CADCOM, INC.  
2024 West Street  
Annapolis, Maryland 21401

John C. Gebhardt  
Vice President, Program Development

Robert B. Thompson  
Member of Technical Staff

CALI AND ASSOCIATES  
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Metairie, Louisiana 70001

Filippo Cali  
President

Donald P. Ross  
Manager, N/C Services

L. W. Lowery  
Consultant

Albrecht Schulze  
Associate

COSMIC  
University of Georgia  
112 Barrow Hall  
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